ELEKTOR ELECTRONICS

THE INTERNATIONAL ELECTRONICS MAGAZINE

December 1993
£ 3.50

Win a prize wth our Christmas Crossword

AUDIO & HI-FI • COMPUTERS & MICROPROCESSORS • DESIGN IDEAS • RADIO, TELEVISION & COMMUNICATIONS • SCIENCE & TECHNOLOGY • TEST & MEASUREMENT

BUMPER CHRISTMAS ISSUE

With over 50 construction projects

Medium power HEXFET amplifier

AF RMS Voltmeter

Choosing component values for *LC* resonant circuits

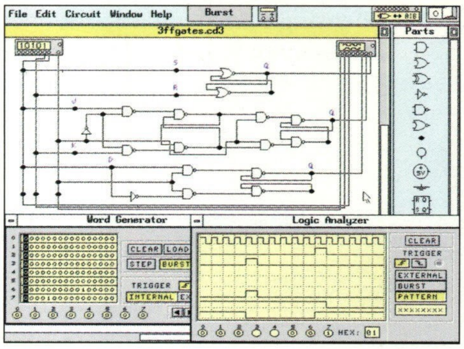
SCART switching box

9 770268 451036 12

Design and Verify Circuits. Fast.

Analog Module includes:

- complete control over all component values
- ideal *and* real-world models for active components
- resistors, capacitors, inductors, transformers, relays, diodes, Zener diodes, LEDs, BJTs, opamps, bulbs, fuses, JFETs, and MOSFETs
- manual, time-delay, voltage-controlled and current-controlled switches
- independent, voltage-controlled and current-controlled sources
- multimeter
- function generator (1 Hz to 1 GHz)
- dual-trace oscilloscope (1 Hz to 1 GHz)
- Bode plotter (1 mHz to 10 GHz)
- SPICE simulation of transient and steady-state response



Digital Module includes:

- fast simulation of ideal components
- AND, OR, XOR, NOT, NAND and NOR gates
- RS, JK and D flip-flops
- LED probes, half-adders, switches and seven-segment displays
- word generator (16 eight-bit words)
- logic analyzer (eight-channel)
- logic converter (converts among gates, truth table and Boolean representations)

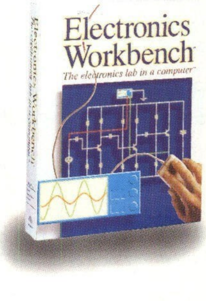
Complement Your Test Bench

Here's why Electronics Workbench belongs on *your* test bench: Wires route themselves. Connections are always perfect. And the simulated components and test instruments work just like the real thing. The instruments are indestructible and the parts bin holds an unlimited supply of each component. The result: thousands of electronics professionals and hobbyists save precious time and money. **Over 90% would recommend it to their friends and colleagues**. Electronics Workbench: the ideal, affordable tool to design and verify your analog and digital circuits before you breadboard.

And now the best is even better – Electronics Workbench Version 3.0 is here. It simulates more and bigger circuits, and sets the standard for ease of use. Guaranteed!

NEW Features in Version 3

- new components include JFETs, MOSFETs, voltage-controlled and current-controlled sources and manual, time-delay, voltage-controlled and current-controlled switches
- real-world models for opamps, BJTs, JFETs, MOSFETs and diodes – over 100 models available
- MS-DOS version now supports up to 16 MB of RAM for simulation of bigger circuits
- new Microsoft® Windows™ version available
- technical support now also available on CompuServe®



Just £199!

Electronics Workbench®

The electronics lab in a computer™

Call: (0827) 66212

ROBINSON MARSHALL (EUROPE) LTD.
17 Middle Entry, Tamworth, Staffordshire, England B79 7NJ
Fax: (0827) 58533

*30-day money-back guarantee.

Shipping charges – UK £4.99. All prices are plus V.A.T.
All trademarks are the property of their respective owners.

INTERACTIVE

ELEKTOR ELECTRONICS

CONTENTS

December 1993
Volume 19
Number 217
ISSN 0268/4519

In next month's issue
(among others):

- Telephone-controlled switch
- RDS decoder
- Digital dial
- I^{2}C tester
- Monochrome VGA adaptor
- Remake RS232
- SIM, an 8051 simulator
- Coding for GSM
- LCD displays
- and others for your continued interest.

Front cover
In spite of their relatively modest TO220 case, the International Rectifier HEXFETs used in the 60-watt output amplifier shown on the cover (and described on pp. 8–13) can cope with fairly large voltages and currents. The amplifier is absolutely symmetrical from input to output. Its mechanical design is such that it can be accommodated on a fairly small printed circuit board, including the electrolytic capacitors of the power supply.

Copyright © 1993 Elektuur BV

ABC
AUDIT BUREAU OF CIRCULATIONS
CONSUMER PRESS

To all our readers: thank you for your continued support during the past year and may peace be with you in the coming year.

57 CHRISTMAS PRIZE CROSSWORD

106 CUMULATIVE INDEX 1993

108 PRODUCT OVERVIEW

AUDIO & HI-FI

8 Medium-power HEXFET amplifier
36 Solid-state voice recorder
38 Stereo PWM output amplifier
45 Peak level indicator
52 Special band-stop filter

COMPUTERS & MICROPROCESSORS

16 535 card with EPROM emulator – Part 2
52 RC-5 infra-red receiver for 80C32
54 Compact A–D converter
74 Hexadecimal display decoder
76 8-channel A–D converter
80 Microcontroller driven UART

GENERAL INTEREST

30 PWM motor control
30 Frequency-operated switch
31 Windscreen wiper control
32 Bicycle light with afterglow
34 I^{2}C EEPROM
36 Active two-wire temperature sensor
39 Optical squelch
40 Low-drop a.c. switch
42 Privacy phone
48 Wind direction indicator
49 Precedence detector
50 Variable differential amplifier
50 Temperature monitor
56 Multi-colour LED
56 Angler's bait indicator
60 Telephone monitor
60 Car interior light delay
64 Automatic twilight switch
64 Basic timer I
65 Long-duration timer
65 Electronic bell-push
68 PCB drill control
70 Basic timer II
72 Video data change detector
73 Complementary doorbell
77 Power booster for slide projectors
84 Figuring it out – Part 11
88 Photographic workshop light
101 I^{2}C power switch

POWER SUPPLIES & BATTERY CHARGERS

20 Views of the bridge – Part 1
32 Solar panel switch
35 Small power converter
42 Button-cell charger
46 Simple d.c. to d.c. converter
48 Regulator short-circuit indicator
54 Battery charging regulator
70 Inexpensive voltage doubler
72 Symmetrical power supply
77 Battery discharger
78 NiMH battery charger
78 Battery voltage monitor

RADIO, TELEVISON & COMMUNICATIONS

44 Infra-red controlled remote switch
45 Basic infra-red transmitter
46 Frequency doubler
62 Low power NBFM transmitter
63 Inexpensive video enhancer
92 SCART switching box
96 Choosing component values for *LC* resonant circuits

TEST & MEASUREMENT

24 RMS AF voltmeter
73 Storage oscilloscope tester

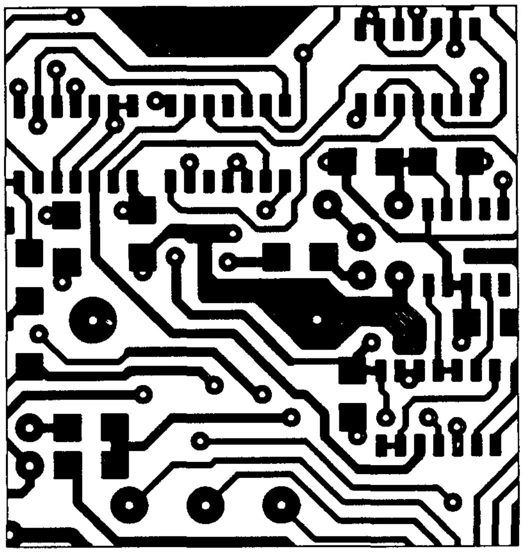
MISCELLANEOUS INFORMATION

5 Electronics scene
110 Readers' services
112 Terms of business
112 Switchboard
113 What's on in December
114 Buyers' guide
114 Index of advertisers

Elektor Electronics is published monthly, except in August, by Elektor Electronics (Publishing), P.O. Box 1414, Dorchester, Dorset DT2 8YH, England. The magazine is available from newsagents, bookshops, and electronics retail outlets, or on subscription at an annual (1994) post paid price of £27·00 in the United Kingdom; air speeded: £34·00 in Europe; £43·00 in Africa, the Middle East and South America; £45·00 in Australia, New Zealand and the Far East; and $57.00 in the USA and Canada. Second Class Postage paid at Rahway N.J. Postmaster: Please send address corrections to Elektor Electronics, c/o Mercury Airfreight International Ltd Inc., 2323 Randolph Avenue, Avenel, New Jersey, N.J. 07001.

EASY-PC, SCHEMATIC and PCB CAD

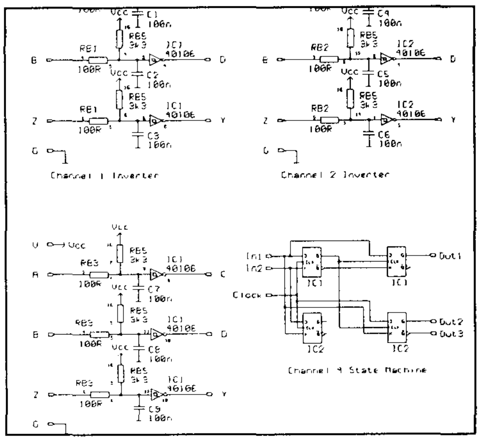
Over 17,000 Installations in 70 Countries World-wide!



- Runs on:- PC/XT/AT/ 286/ 386/ 486 with Hercules, CGA, EGA or VGA display and many DOS emulations.
- Design:- Single sided, Double sided and Multi-layer (8) boards.
- Provides full Surface Mount support.
- Standard output includes Dot Matrix / Laser / Ink-jet Printer, Pen Plotter, Photo-plotter and N.C. Drill.
- Tech Support - free.
- Superbly easy to use.

Still Only £98.00! Plus P&P+VAT

BRITISH DESIGN AWARD 1989

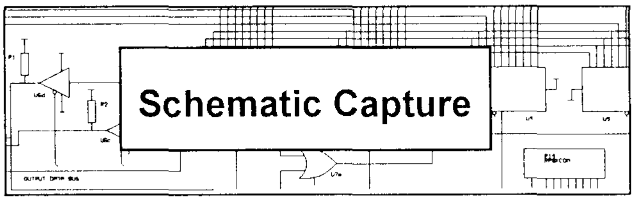


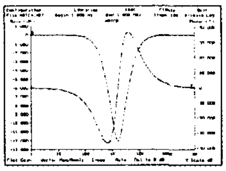
Options:-500 piece Surface Mount Symbol Library £48, 1000 piece Symbol Library £38, Gerber Import facility £98.

Electronic Designs Right First Time?

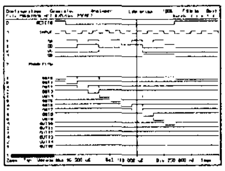
Ask for our fully functional Integrated Demo

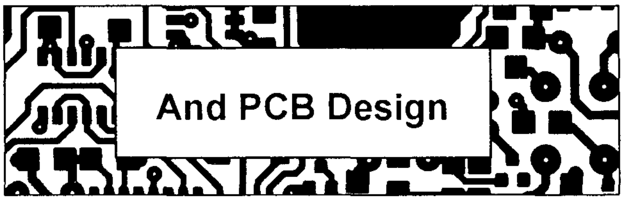
Integrated Electronics CAD





Analogue & Digital Simulation





For Less than £400/$775!

Affordable Electronics CAD

EASY-PC: Low cost, entry level PCB and Schematic CAD.	$195.00	£98.00
EASY-PC Professional: Schematic Capture and PCB CAD. Links directly to ANALYSER III and PULSAR.	$375.00	£195.00
PULSAR: Low cost Digital Circuit Simulator ~ 1500 gate capacity.	$195.00	£98.00
PULSAR Professional: Digital Circuit Simulator ~ 50,000 gate capacity.	$375.00	£195.00
ANALYSER III: Low cost Linear Analogue Circuit Simulator ~ 130 node capability	$195.00	£98.00
ANALYSER III Professional: Linear Analogue Circuit Simulator ~ 750 node capability.	$375.00	£195.00
Z-MATCH for Windows: NEW Windows Smith-Chart program for RF Engineers .	$475.00	£245.00
We operate a no penalty upgrade policy. You can upgrade at any time to the professional version of a program just for the difference in price.	*US$ prices include Post and Packing.*	*UK£ prices exclude P&P and VAT*

For full information, Write, Phone or Fax:-

Number One Systems Ltd. 1

- TECHNICAL SUPPORT FREE FOR LIFE!
- PROGRAMS NOT COPY PROTECTED.
- SPECIAL PRICES FOR EDUCATION.

REF: EK, HARDING WAY, ST.IVES, HUNTINGDON, CAMBS, ENGLAND, PE17 4WR.
Telephone UK: 0480 461778 (7 lines) Fax: 0480 494042
USA: (415) 968 9306 International +44 480 461778 ACCESS, AMEX, MASTERCARD, VISA Welcome.

ELECTRONICS SCENE

FREE A-D SPICE SIMULATOR FOR *ELEKTOR ELECTRONICS* READERS

TopSPICE is a new SPICE compatible analogue simulator with integrated event driven digital simulation, analogue behavioural modelling and optional schematic entry. It costs £395 for the 640K only version, £695 for the 32-bit version with unlimited capacity and £149 for the schematic entry option. This makes it the only affordable true-mixed analoge and digital SPICE simulator available. A **FREE**, fully working evaluation version is available to any *Elektor Electronics* reader who sends a 1.44MB formatted 3.5" DS HD disk to:

Elektor Offer
CRaG Systems
8 Shakespeare Road
Thatcham, Newbury
Berkshire RG13 4DG
England

The free version simulates circuits with up to 10 transistors or gates and makes an ideal first simulator. For those unfamiliar with SPICE based simulation, the book *PSpice and Circuit Analysis* by John Keown is available from CRaG Systems at £39.95 plus £2 p&p. It describes in detail the syntax and analyses of the SPICE language and contains many simulation examples that run on the free version of TopSPICE. Together, they make a great introductory 'kit'.

CRaG Systems was set up to service the electronics industry with high performance, affordable and easy-to-use computer-aided engineering (CAE) software running on PCs. The company aims to offer the customer the same level of service that he would expect from the manufacturers. This includes a high level of technical support to ensure that the end-user is up and running as quickly as possible with a new piece of software.

TopSPICE integrates a complete SPICE analogue simulator with behavioural modelling capability and an event-driven logic simulator to allow simulation of circuits containing any arbitrary combination of analogue devices, digital components and high-level behavioural blocks. It enables the user to verify and optimize his design from the system to the transistor level.

THE VERSATILITY OF ISDN

By Adrian Morant

Although at one time ISDN was said to stand for "Innovations Subscribers Don't Need", there is a wide range of applications already in place in the United Kingdom. The system is used by both 'knowledge workers' and those carrying out routine tasks from their homes, instead of from a normal office, in addition to widely-touted applications such as Group 4 fax and video-conferencing.

The UK has been in the forefront of developments, with British Telecom (BT) having introduced its IDA (Integrated Digital Access) pilot service in June 1985. It offered two channels, one at 64 kbit/s and the other at 8 kbit/s. By 1988 it was available in 60 towns throughout Britain.

This was not in accordance with the CCITT's (Consultative Committee for Telephones & Telegraphs) 'Red Book' of ISDN recommendations which was published in 1984. However, while a number of operators followed these recommendations, the CCITT 1988 'Blue Book' of recommendations contains significant changes and clarifications which should lead to truly international standards.

First operator. BT, having by-passed the Red Book, is probably the first operator to implement the Blue Book requirements. According to the latest figures available, at the middle of February 1993, BT had installed 17,950 'B' channels at Basic Raye Access (BRA) and 108,000 'B' channels at primary rate. It is difficult to correlate the latter figure with the actual number of Primary Rate Access (PRA) users, as users no longer have to take full 30-channel PRAS, but are able to buy as small a number as 15 channels.

Usage is not limited to the urban conurbations. The Highland and Islands Region of Scotland is the beneficiary of EC funding under the STAR programme aimed at providing modern communications to rural areas of the European Community. Consequently, today it has an excellent fibre-optic infra-structure and an availability of ISDN second to none with both PRA and BRA being readily available.

On-line database. One of the most interesting applications is the use of ISDN to process medical and scientific articles for an on-line database. Pioneered by Crossaig, this reduces the time taken for published journals to appear in the Elsevier Embase database from one month, when the work is carried out manually, to just one week.

Crossaig's four permanent staff at the company's office in Helensburgh scan articles and store the images in the computer. Optical Character Recognition (OCR) is then used to convert the image into text. Each outworker, who is a specalist in the appropriate medically-related discipline, is equipped with a standard IBM-compatible PC which is linked to Helensburgh over ISDN2 (BT's name for BRA) by a Gravatom SO PC card which converts the PC into an ISDN terminal.

It takes some eight seconds to send a typical file between Helensburgh and the appropriate medical expert's home which may be in Perth, Glasgow or some other part of Scotland. Each article is then indexed under the 160,000 medical terms listed in Elsevier's thesaurus. When the task is completed, the indexed work is sent back over the ISDN connection to Helensburgh and then on to Amsterdam to Elsevier Science Publishing.

Specialist editors. Crossaig's goal is to edit all of the 100,000 English-language articles from UK journals that are downloaded annually into the Embase database. To achieve this, they aim to have 50 specialist editors who can be located anywhere in Scotland.

In conjunction with the Highlands and Islands Development Board, Crossaig is also looking at ways of using its skills to process other kinds of information.

A totally different application of ISDN is on trial by BT itself. It is engaged in a 12-month trial in which ten volunteer directory assistance operators are working in the comfort of their homes around Inverness, rather than from an office in the telephone exchange in the centre of town. The purpose of the experiment is to investigate the technical, managerial and social aspects of teleworking, so that systems can be developed to satisfy the increasing demand for alternative ways of working.

The volunteers have specially adapted terminals installed in their homes, giving them all the on-line facilities available in the centre. To counter any feelings of isolation, they are also linked by videophones. This gives them direct contact with their supervisor and, during breaks, allows them to chat to each other or catch up with the office gossip through another videophone installed in the centre's rest room.

Expensive equipment. A problem frequently encountered with hi-tech medicine is that of taking the mountain to Mohammed. Modern diagnostic equipment is exceedingly expensive and often can not be moved. At the same time, there is a great deal of pressure on specialists' time.

Magnetic resonance imaging/computerized tomography (MRI/CT) has brought vast improvements over traditional X-rays as a medical diagnostic tool, one of the benefits being the enhanced contrast that enables soft tissue to be differentiated from its surroundings. However, as can be expected with any high resolution imaging, the price to be paid is the vast amount of data in each image.

Simis Medical Imaging has installed a system at the Kent Oncology Centre at Maidstone, which is using ISDN to transmit 256×256×16 bit MRI images from the scanner to a remote location where they can be viewed by the specialists. To transmit each image in the acceptable time of around one minute, they reverse-multiplex eight 'B' channels.

The Wales Information Network (WIN) uses BRA to link ten Training and Enterprise

Councils (TECs) in Wales to provide individuals with immediate access to information on education, training and career opportunities. Previously, information now available from WIN was sourced from stand-alone PCs and transported via floppy discs.

Technical expertise. WIN has appointed Jaguar Communications (which was also the supplier to Simis) as its sole supplier. According to WIN manager Linda Tomos, “We decided to use ISDN as we believe it will provide the best framework for long-term growth and development of the network. We had worked with Jaguar in the past with good results and were confident in their technical expertise. This was particularly important as ISDN is a new technology to us, so we had to be assured that our supplier could provide advice and support as well as equipment.”

WIN is now actively encouraging a wide number of partners, such as employers, careers advisers and educational establishments to join the network in order to increase the range of information sources available.

THE MOLECULAR DIODE PROMISES ELECTRONIC FLEXIBILITY

By A.S. Martin and J.R. Sambles
Department of Physics
University of Exeter

In these days of ever-increasing electronic circuit speed and complexity, Molecular Electronics (ME) is providing an exciting and distinctly different viewpoint of the future of electronic devices. While conventional technology advances largely by packing more devices on to a single chip, by improved lithographic techniques, lower device failure rates and more efficient interconnects, the molecular alternative depends on continually re-inventing the basic building blocks on a molecular level, thus tailoring the molecular structure to the application in hand.

It is precisely this inherent flexibility, essentially limited only by human ingenuity, in which the strength and future of ME lies. Of course, compared with conventional electronics, ME is still in its infancy, but with widespread research providing relationships between molecular deign and device properties, it is feasible that a proliferation of devices will occur in the (near) future.

Desirable goal. Following the early development of semiconductor technology, it has been considered that demonstration of analogous electrical behaviour in molecular devices constitutes a desirable goal. That is, to build a molecular diode and then a molecularly-based transistor. In achieving these aims, the most difficult hurdle is to form the connections between the molecules comprising the device and the external measurement circuitry. This constitutes the main reason for the limited success of such projects in preceding decades.

While attempts to address single molecules have been made, using modified scanning tunnelling microscopes, there are, as yet, no reliable results. Without the ability to interrogate single molecules, researchers are forced to study thin film samples. In this way, a two-dimensional array of identical molecules may be sampled with only the third dimension reduced to the molecular length scale. It is then a matter of attaching metallic electrodes to opposite sides of a molecular film.

Langmuir-Blodgett technique. Clearly, it is sensible to use the solid support for the organic films as one electrode. In this research programme, a carefully prepared glass slide, coated with silver on one side, was used. The molecular organic film was then deposited on to this fresh metallic surface, using the Langmuir-Blodgett (LB) transfer technique. A solution of the molecules, in a sufficiently voltatile solvent, is introduced on to an ultra-pure water/air interface where, on evaporation of the solvent, the molecules remain.

In order to form a suitably stable monolayer (termed a Langmuir film), there are certain constraints on the molecular structure. Most importantly, the molecule must not be soluble in water and, to this end, it must possess a moiety of hydrophobicity. Typically, this is achieved by the attachment of a chain of numerous CH_2 subunits, the number of subunits usually lying between 10 and the low 20s. Shorter chains do not possess the required insolubility characteristics and longer chains become too flexible and are considered to compromise monolayer formation. In addition to hydrophobic moiety, an hydro-phylic section is also important for both monolayer formation and transfer on to a solid support. This anchors part of the molecule into the water surface and, therefore, causes molecular orientation at the air/water interface.

Long molecules. Generally, the most favourable materials for LB deposition are long molecules, consisting of an hydrophylic headgroup and an hydrophobic tail. The natural orientation at the air/water interface may be further improved by a compression of the monolayer. This is achieved by reducing the surface area within which the monolayer is constrained. Once the optimum film conditions have been attained, using a computerized measurement and feedback system, the solid support (sub-

Produced and published by **ELEKTOR ELECTRONICS (Publishing)**

Editor/publisher: Len Seymour
Technical Editor: J. Buiting

Editorial & Administrative Offices:
P.O. Box 1414
DORCHESTER DT2 8YH
England
Telephone: (0305) 250 995 (*National*)
or +44 305 250 995 (*International*)
Fax: (0305) 250 996 (*National*)
or +44 305 250 996 (*International*)

U.K. Advertising Office:
3 Crescent Terrace
CHELTENHAM GL50 3PE
Telephone: (0242) 510 760
Fax: (0242) 226 626

International Advertising Office:
Elektuur BV
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
Fax: +31 46 37 01 61

Subscriptions:
World Wide Subscription Service Ltd.
Unit 4, Gibbs Reed Farm
Pashley Road
TICEHURST TN5 7HE
Telephone: (0580) 200 657 (*National*)
or +44 580 200 657 (*International*)
Fax: (0580) 200 616 (*National*)
or +44 580 200 616 (*International*)

Head Office:
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
Telex: 56617 (elekt nl)
Fax: +31 46 37 01 61
Managing Director: M.M.J. Landman

Distribution:
SEYMOUR
1270 London Road
LONDON SW16 4DH

Printed in the Netherlands by NDB, Zoeterwoude

Overseas editions:
FRANCE
Elektor sarl
Les Trois Tilleuls
B.P. 59; 59850 NIEPPE
Editor: G.C.P. Raedersdorf

GERMANY
Elektor Verlag GmbH
Süsterfeld Straße 25
5100 AACHEN
Editor: E.J.A. Krempelsauer

GREECE
Elektor EPE
Kariskaki 14
16673 Voula—ATHENA
Editor: E. Xanthoulis

HUNGARY
Elektor Elektronikai folyórat
1015 Budapest
Batthyány u. 13
Editor: Lakatos András

INDIA
Elektor Electronics PVT Ltd
Chhotani Building
52C, Proctor Road, Grant Road (E)
BOMBAY 400 007
Editor: C.R. Chandarana

ISRAEL
Elektorcal
P O Box 41096
TEL AVIV 61410
Publisher: M. Avraham

NETHERLANDS
Elektuur BV
Peter Treckpoelstraat 2–4
6191 VK BEEK
Editor: P.E.L. Kersemakers

POLAND
Elektor Elektronik
02–777 Warszawa 130
Skrytka Pocztowa 271
Editor: W. Marciniak

PORTUGAL
Ferreira & Bento Lda.
R.D. Estefâni, 32-1°
1000 LISBOA
Editor: F. Ferreira de Almeida

SPAIN
Resistor Electronica Aplicada
Calle Maudes 15 Entlo C.
28003 MADRID
Editor: Agustin Gonzales Buelta

SWEDEN
Electronic Press AB
Box 5505
14105 HUDDINGE
Editor: Bill Cedrum

strate) is introduced vertically into the water. Depending on the molecular species used and the relevant conditions, a monolayer may be transferred from the water surface on to the substrate during the immersion. Subsequent removal of the substrate from the water may also transfer a monolayer. Transfer on both down- and up-strokes leads to a centrosymmetric molecular film in which adjacent monolayers have opposite orientations (termed *Y*-type), while transfer only on the up-strokes forms non-centrosymmetric structures with all the molecula headgroups oriented towards the substrate (*Z*-type). Multilayer films are formed by multiple repetitions of the immersion/emersion process.

The molecules used during this study ($C_{16}H_{33}$-γQ3CNQ) were synthesized at the Centre for Molecular Electronics at Cranfield Institute of Technology and fall into the category described above, but additionally contain achromophore moiety at the headgroup. The zwitterionic chromophore is composed of an electron donor and acceptor separated by a sigma-bonded bridge. The charge transfer resonance causes the solid film to appear deep blue in colour and is responsible for the expectation of diode-type behaviour. LB deposited films belong to the *Z*-type class.

Magnesium pads. On to these LB multilayers, a second electrode must be deposited. Vacuum deposited magnesium pads ensure electrical contact with a minimum of damage to the underlying LB film. Smaller silver pads are deposited on to these to prevent magnesium oxide formation. A droplet of gallium-indium eutectic is carefully placed on the silver pad, thus preventing transfer of mechanical stress to the LB film, when a gold wire is lowered into the liquid metal. Double overlapping electrodes are used to carry out continuity checks on this composite electrode. Connection to the silver substrate then completes the sample circuit. Cyclic voltametry is used in the electrical characterization, that is, a swept voltage is applied to the sample and the current passed by the sample is measured with an electrometer.

Plots of current-density versus voltage (J/V) for an LB layer of seven monlayers show that with forward bias (defined as the substrate electrode positive), a much larger current is passed than with a corresponding voltage of opposite sense. Publication of such data proved controversial with suggestions that, rather then being molecular in origin, the reason for asymmetric conduction might lie alternatively with the presence of interfacial regions between the metallic electrodes and the LB film. This has been disproved in two ways.

Firstly, through selective destruction of the charge transfer resonance (carried out as a Langmuir film on the water surface). Fabrication of these altered molecules into samples gave current-density versus voltage (J/V) data similar to the unaltered films except in the one important aspect that the large forward bias current was absent. Thus, a link between the optical resonance and the electrical behaviour had been established, although it does not rule out different types of Schottky barriers for the two cases. The second, and more rigorous, test was the fabrication of a sample in which the active organic film was separated from the metallic electrodes by LB layers of the inert material κ-tricosenoic acid, the rationale being that these prevented the formation of potentially electrically asymmetric interfacial regions. J/V data was, again, observed to exhibit the diode-type feature.

Project continues. The unequivocal conclusion is that the diode-like electrical data are a manifestation of the molecular structure. Having demonstrated diode behaviour with a molecular film, the progression of the project continues along several lines. The researchers have preliminary results to suggest that these materials form molecular photodiodes when the silvered substrate is replaced by a transparent electrode. Optimization of the molecular structure is important, both in the interest of expected improvements, as well as the ultimate goal of device manufacture. The team is, therefore, currently studying other materials, some consisting of subtly different and others radically different molecular moieties. The production of a 'molecular transistor' is extremely unlikely if one takes the narrow view of a single molecule requiring three separate molecular connections, but if, instead, a molecular device behaving as a transistor is envisaged, then realization is significantly more attainable by the combination of two molecular diodes.

While there are plans to implement such ideas in the near future, whether they will function is a matter of considerable interest.

LLOYD RESEARCH SOLVES THE OTP MICRO PROGRAMMING PROBLEM

Although OTP microcontrollers are becoming popular, they have proved difficult to program, particularly in production. Lloyd Research has solved this problem by introducing two new modules – as opposed to socket adaptors – for Hitachi micros that can be fitted into their L9000 range of programmers. The L9000 programmer, with two module bays, is ideal because a single module can be used in R&D and an additional module can be fitted for production.

The new modules, the PL532, which caters for the 84-pin H8/6475328 in PLCC package, and the PL432 for the 4074329 quad flat pack, are very economical compared with 'of the shelf' socket adaptors. For instance, the PL532 two-socket module costs just £300, which is less than the cost of two typical socket adaptors.

The purpose-designed module and built-in software make the L9000 ideal for production. For example, many production programmers stop programming when one device fails, leaving most devices in a partially programmed state, whereas, in most circumstances, the L9000 will continue programming.

Master data can either be read from a master device or down-loaded from a host, typically a PC. Increasingly, production departments are holding master data on a PC. To cater for this trend, the L9000 can be driven from a simple DOS batch file. Therefore, by typing a single word, the L9000 can down-load the master data and select the correct device type. All the operator has to do is to fit blank devices and press a single button to start programming. Once data has been own-loaded, the PC is no longer required.

The L9000 has many other modules for EPROMs in different packages, such as PLCC or LCC, as well as for other microcontrollers. With type approvals from Intel, Texas Instruments and Signetics, the L9000 is ideal in production as well as R&D.

See advertisement on page 23.

QUICKROUTE 2.0 FOR WINDOWS

Quickroute 2.0 for Windows 3/3.1 is a PCB and schematic design package developed and sold by POWERware Software Design. During the past 12 months, the package has steadily penetrated the educational market, thanks to the appeal of *Elektor Electronics* at the 'chalk face'.

As a result of this success and feedback from teachers, POWERware are committed to a continuous programme of development with their Quickroute software, specifically with learning in mind.

Of particular interest to teachers will be the release in the near future of a student booklet to accompany the teachers manual for Quickroute.

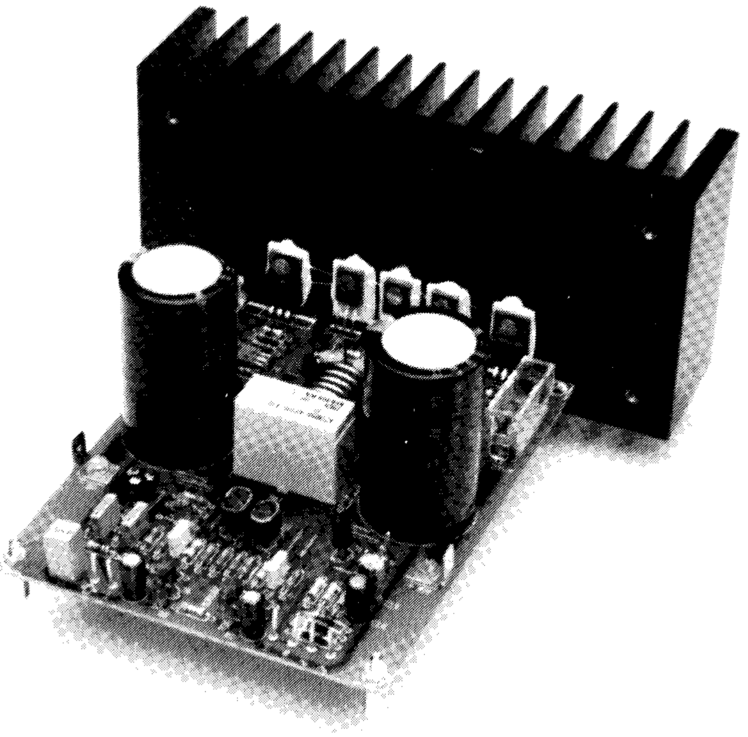
A review in the May 1993 issue of *Radio Communications* said: "Quickroute provides a comprehensive and effective introduction to PCB design, which is a pleasure to use".

Electronics & Wireless World, in their July 1993 issue, stated: "Windows fans will immediately feel at home with the screen layout of Quickroute 2 – the upgraded low-cost PCB design package now given a Windows interface and netlisting capability. It takes, literally, minutes to start exploiting Quickroute where traditionally CAD packages are an acquired taste. While this is unlikely to be relevant in a professional application where users are working with a package day in, day out, in a teaching environment students can concentrate on the engineering rather than wasting time learning the key presses."

Durng the NDTEF Summer School at York University last August, POWERware was invited to present Quickroute products to teachers. Groups comprising teachers from various IT backgrounds enjoyed what they saw, even if they did not fully understand electronics.

See advertisement on page 55.

MEDIUM POWER HEXFET AMPLIFIER



Design by T. Giesberts

In spite of their relatively modest TO220 case, the International Rectifier HEXFETs used in the present 60-watt output amplifier can cope with fairly large voltages and currents. The amplifier is absolutely symmetrical from input to output. Its mechanical design is such that it can be accommodated on a fairly small printed-circuit board, including the electrolytic capacitors of the power supply.

The design objective was to arrive at a not too complex unit that nevertheless offered excellent performance, was fairly simple to build and could be reproduced relatively easily. The result is a straightforward amplifier without any unnecessary gimmicks.

A bipolar transistor may be considered a current-amplifying device that enables a (relatively) large current to be controlled by a much smaller one. A field-effect transistor (FET) behaves differently: it is a sort of variable resistance whose conduction is controlled by a voltage. It follows that the drives of these devices is quite different: an important consideration in the design of an output amplifier. A bipolar transistor needs a base current before it can function, whereas a FET can be driven almost without any energy. All it needs is a control voltage; the current it draws is negligible. When power FETs first came on to the market, many designers thought that they would simplify the design of output amplifiers beyond belief. That quickly proved to be not so, however, because power FETs have a fairly large capacitance between the gate and the drain/source channel (sometimes of the order of a few nanofards). This means that at high audio frequencies the driver stages need to deliver fairly large transfer currents to keep the bandwidth sufficiently large.

It may well be asked what advantage(s) a FET offers. In a bipolar power transistor, it is difficult to combine high voltage, large current, and wide bandwidth, because its operation must remain within the Safe Operating Area—SOA. It is not enough to just look at the peak voltage and current in the relevant data sheet. By virtue of modern production techniques, FETs can be fabricated that can handle high voltages (100 V and more) and, in spite of their modest dimensions, large currents. It is, therefore, much simpler to design an output amplifier with reasonable power output with power FETs than with power transistors. Of course, there are other requirements as well, such as slew rate and matching of complementary semiconductors ...

The circuit

A symmetrical design has the advantage that it minimizes problems with distortion, particularly that associated with even harmonics. Therefore, the input stages consist of two differential amplifiers, T_1-T_2 and T_3-T_4. These use discrete transistors, not expensive dual devices, to keep the cost down. Performance is excellent, particularly if the transistors are matched.

A differential amplifier is one of the best means of combining two electrical signals: here, the input signal and the feedback signal. The amplification of the stage is determined mainly by the ratio of the collector and emitter resistances (in the case of T_1-T_2 these are R_9, R_{10}, R_{11} and R_{12}). These form a sort of local feedback: limiting the amplification reduces the distortion.

Two *RC* networks (R_3-C_3 and R_4-C_4) limit the bandwidth of the differential amplifiers and these determine, to a degree, the open-loop bandwidth of the entire amplifier (which is 6.5 kHz).

Brief technical data

Input sensitivity	1 V r.m.s.
Input impedance	48 kΩ
Power output (1 kHz, 0.1% THD)	63 W into 8 Ω 105 W into 4 Ω
Music power (500 Hz burst, 5 cycles on 5 cycles off)	68 W into 8 Ω 120 W into 4 Ω
Power bandwidth (35 W into 8 Ω)	1.5 Hz–125 kHz (+0 dB, –3 dB)
Slew rate	20 V μs^{-1} (with input filter)
Signal-to-noise ratio (1 W into 8 Ω)	>99 dB (A-weighted)
Harmonic distortion (1 W into 8 Ω)	<0.006% (1 kHz)
(60 W into 8 Ω)	<0.005% (1 kHz) <0.05% (20 Hz–20 kHz)
Intermodulation distortion (50 Hz : 7 kHz; 4 : 1)	<0.008% (35 W into 8 Ω)
Dynamic intermodulation distortion rectangular 3.15 kHz + sine wave 15 kHz)	<0.003% (35 W into 8 Ω)
Damping factor (at 8 Ω)	>160 (20 Hz–20 kHz)
Supply voltage	±35 V
Quiescent current (T_{12} and T_{13})	200 mA

The d.c. operating point of the differential amplifiers is provided by two current sources. Transistor T_6, in conjunction with R_{18} and D_2, provides a constant current of about 2 mA for T_1-T_2. Transistor T_5, with R_{17} and D_1, provides a similar current for T_3-T_4. The combination of a transistor and an LED creates a current source that is largely independent of temperature, since the temperature coefficients of the LED and the transistor are virtually the same. It is, however, necessary that these two components are thermally coupled (or nearly so) and they are, therefore, located side by side on the printed-circuit board.

In the input stage, C_1 is followed by a low-pass section, R_1-C_2, which limits the bandwidth of the input to a value that the amplifier can handle. Resistor R_2 is the base resistor of T_1 and T_3. So far, this is all pretty normal. Network P_1-R_7-R_8 is somewhat out of the ordinary, however. It forms an offset control to adjust the direct voltage at the output of the amplifier to zero. Such a control is normally found **after** the input stage. The advantage of putting it before that stage is that the inputs of the differential amplifiers are exactly at earth potential, which means that the noise contribution of their base resistors is negligible.

The signals at the collectors of T_1 and T_3 are fed to pre-drivers T_8 and T_9. Between these transistors is a 'variable zener' formed by T_7 which, in conjunction with P_2, serves to set the quiescent current of the output FETS.

The output of the pre-drivers is applied to T_{10} and T_{11}, which drive HEXFETS T_{12} and T_{13}. This power section has local feedback (R_{30}-R_{31}).

The design of T_{10}–T_{13} is a kind of compound output stage, since the drain of the power FETS is connected to the output terminal. Note that T_{12} is a p-channel FET and T_{13} an n-channel type. Therefore, the stage provides current amplification as well as voltage amplification. The voltage amplification is limited to ×3 by the local feedback resistors (R_{30}-R_{31}). Here again, this feedback serves to reduce the distortion. The overall feedback of the amplifier is provided by R_5-R-C_5.

Fuses are provided in the source lines of the HEXFETS. Power FETS have an inherent current limitation by virtue of their positive temperature coefficient: when the device gets hot, its drain-source resistance rises and this reduces the current through it. The fuses and this property pro-

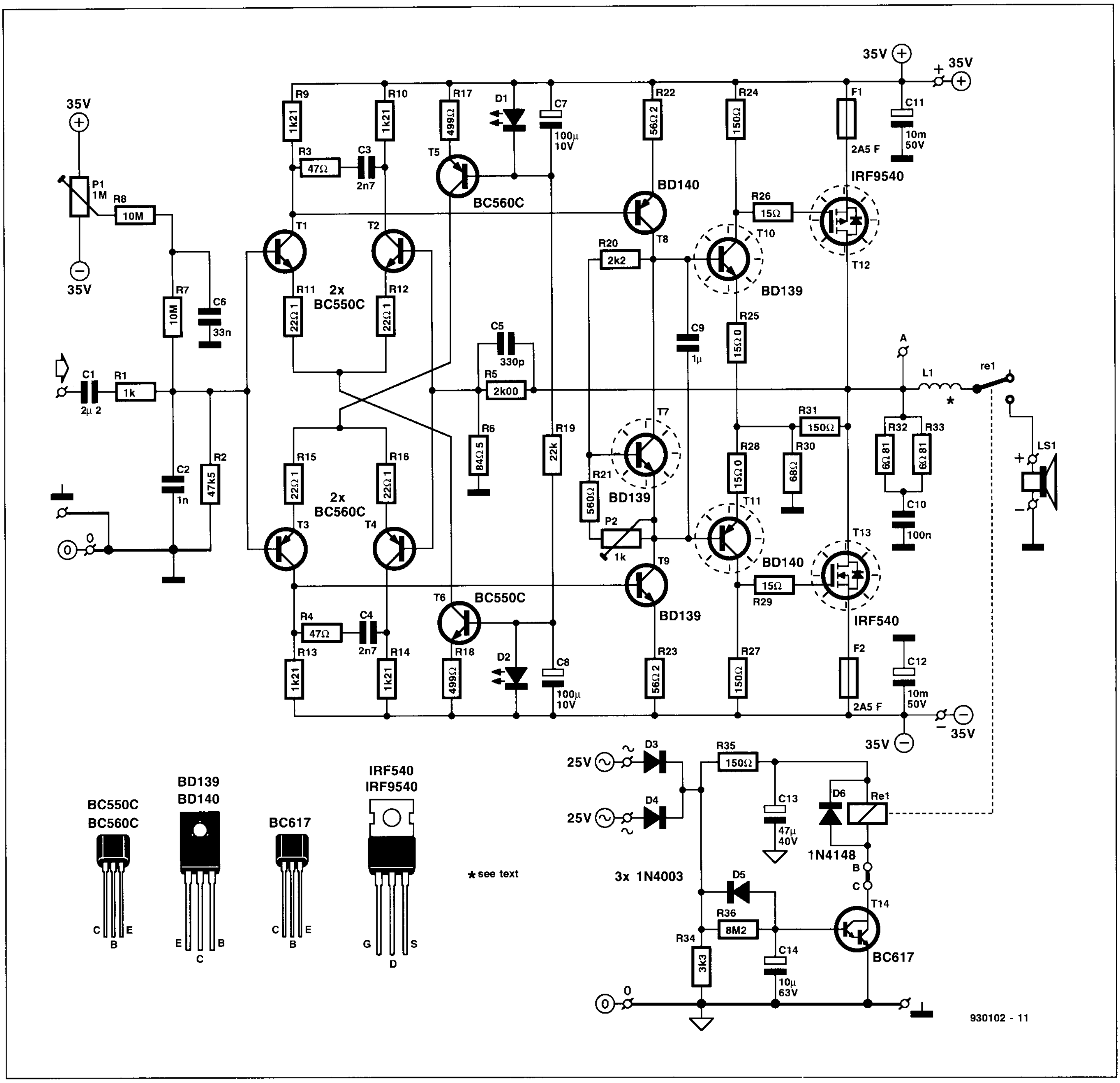


Fig. 1. Circuit diagram of the medium power HEXFET amplifier.

vide adequate protection against brief short-circuits. Note that the HEXFETs used can handle peak currents of up to 75 A. Electrolytic capacitors C_{11} and C_{12} (10,000 µF each and part of the power supply) are located close to the FETs, so that the heavy currents have only a short path to follow.

At the output is a Boucherot network, R_{32}-R_{33}-C_{10}, that ensures an adequate load on the amplifier at high frequencies, since the impedance of the loudspeaker, because of its inductive character, is fairly high at high frequencies.

Inductor L_1 limits any current peaks that may arise with capacitive loads.

The signal is finally applied to the loudspeaker, LS_1, via relay contact Re_1. The relay is not energized for a few seconds after the power is switched on to obviate any plops from the loudspeaker. Such plops are caused by brief variations in the direct supply voltage arising in the short period that the amplifier needs to reach its correct operating level.

The supply voltage for the relay is derived directly from the mains transformer via D_3 and D_4. This has the advantage that the relay is deactuated, by virtue of the low value of C_{13}, immediately the supply voltage fails. The delay in energizing the relay is provided by T_{14} in conjunction with R_{36} and C_{14}. It takes a few second before the potential across C_{14} has risen to a value at which T_{14} switches on. This darlington transistor requires a base voltage of not less than 1.2 V before it can conduct.

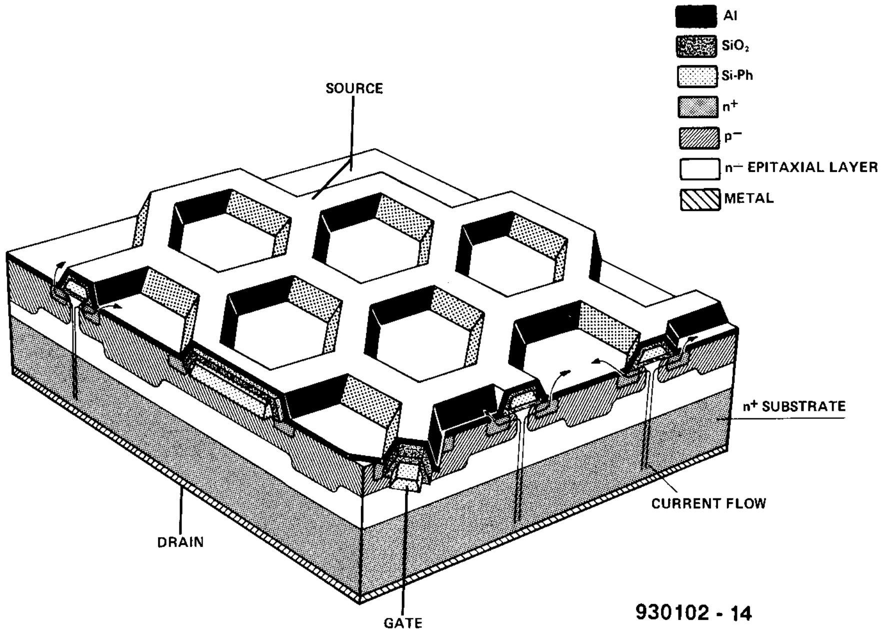
The power supply—see **Fig. 2**—is traditional, apart from the resistors, R_5–R_8 in the power lines. These limit, to some degree, the very large peak charging currents to electrolytic capacitors C_{11} and C_{12}. Moreover, together with these capacitors, they form a filter that prevents most spurious voltages from reaching the amplifier. Measurements on the prototype showed that this was particularly evident at frequencies below 500 Hz.

The HEXFET structure

As implied, the HEXFET structure involves an hexagonal device geometry. At the core is a radically new hexagonal, cellular structure as illustrated. It is this hexagonal geometry, along with advanced MOS processing, that gives the HEXFET an on-state resistance, R_{DSon}, one-third of that possible with the best previous MOSFET technology, in a given die size.

A planar, non-V-groove structure, the HEXFET conducts current vertically. For high packaging density, it uses a silicon-gate structure. The density of the hexagonal source cells on the top surface of the silicon die is over half a million cells per square inch. Electrons flow from a source cell through the channel which is around the periphery of that cell and then into the drain body. The bottom surface of the drain body is in electrical and thermal contact with the holder.

The efficient hexagonal source pattern, the silicon gate, and advanced MOS processing techniques combine to produce the HEXFET's unique performance.



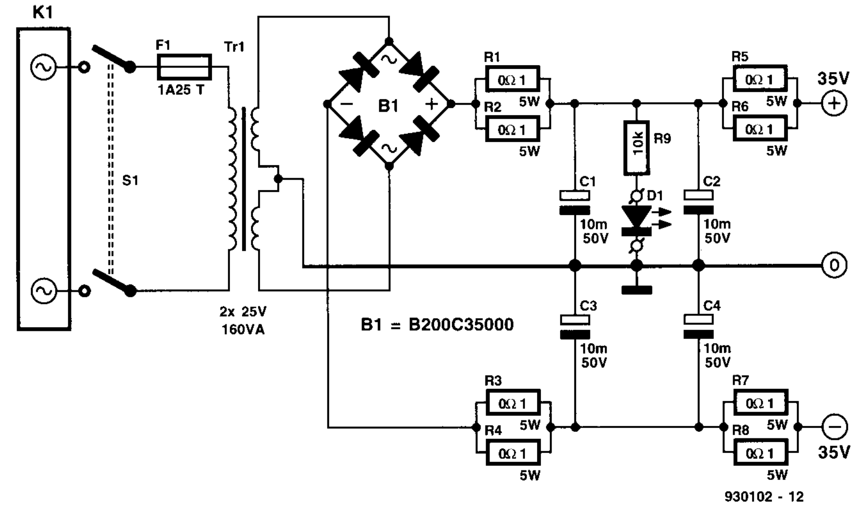


Fig. 2. Circuit diagram of the power supply for the HEXFET amplifier.

Construction

The design of the printed-circuit board for the amplifier (**Fig. 4**) takes good account of the large currents that flow in the amplifier. This has given rise to a couple of tracks being paralleled instead of combined, so that the effect of currents in the power section on the input stages is minimal.

Populating the board is straightforward. Although not strictly necessary, it is advisable to match the transistors used in the differential amplifiers. This may be done conveniently on an h_{fe} tester by measuring the amplification at a collector current of about 1 mA. If such a tester is not available, use a base resistor that results in a collector current of about 1 mA measured with a multimeter. With the same resistor, test a number of other transistors and note the collector currents. Mount the selected pairs on the board and pack them closely together with a 5 mm wide copper ring (made from a piece of 12 mm copper water pipe) as shown in **Fig. 5**.

Inductor L_1 consists of six turns, inner diameter 16 mm (5/8 in), of insulated copper wire 1.5 mm (1/16 in) thick.

The large transistors are located on one side of the board, so that they can be fixed directly to the heat sink. They must be insulated with the aid of ceramic washers.

The two sizes indicated on the board for T_{12} and T_{13} may be ignored: they are a precaution for possible different types of transistor at a later stage.

Connections from the power supply and to the loudspeaker are by means of terminal blocks that can be screwed on to the board.

Mount the two amplifier boards, mains

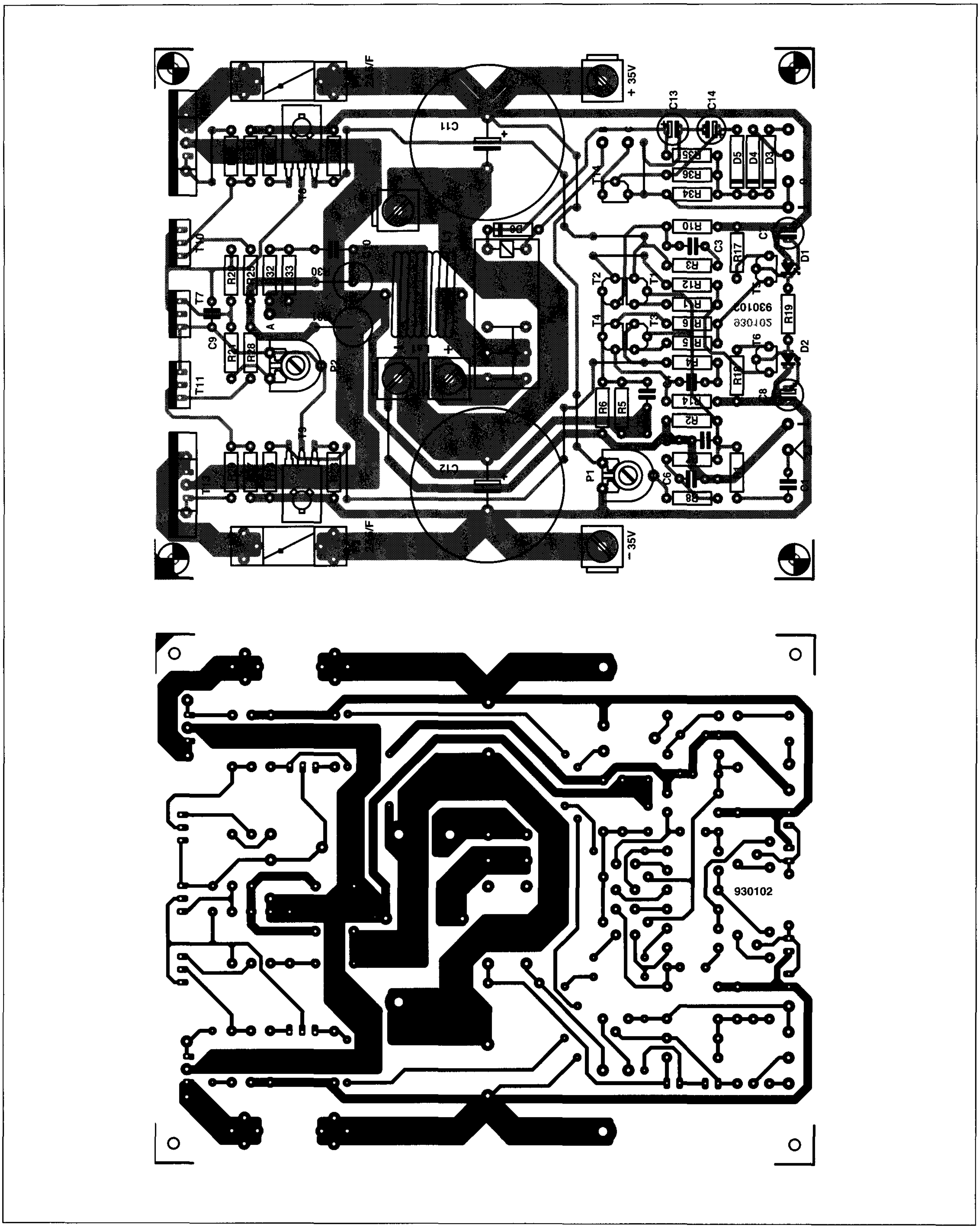


Fig. 3. Printed-circuit board for the medium power HEXFET amplifier.

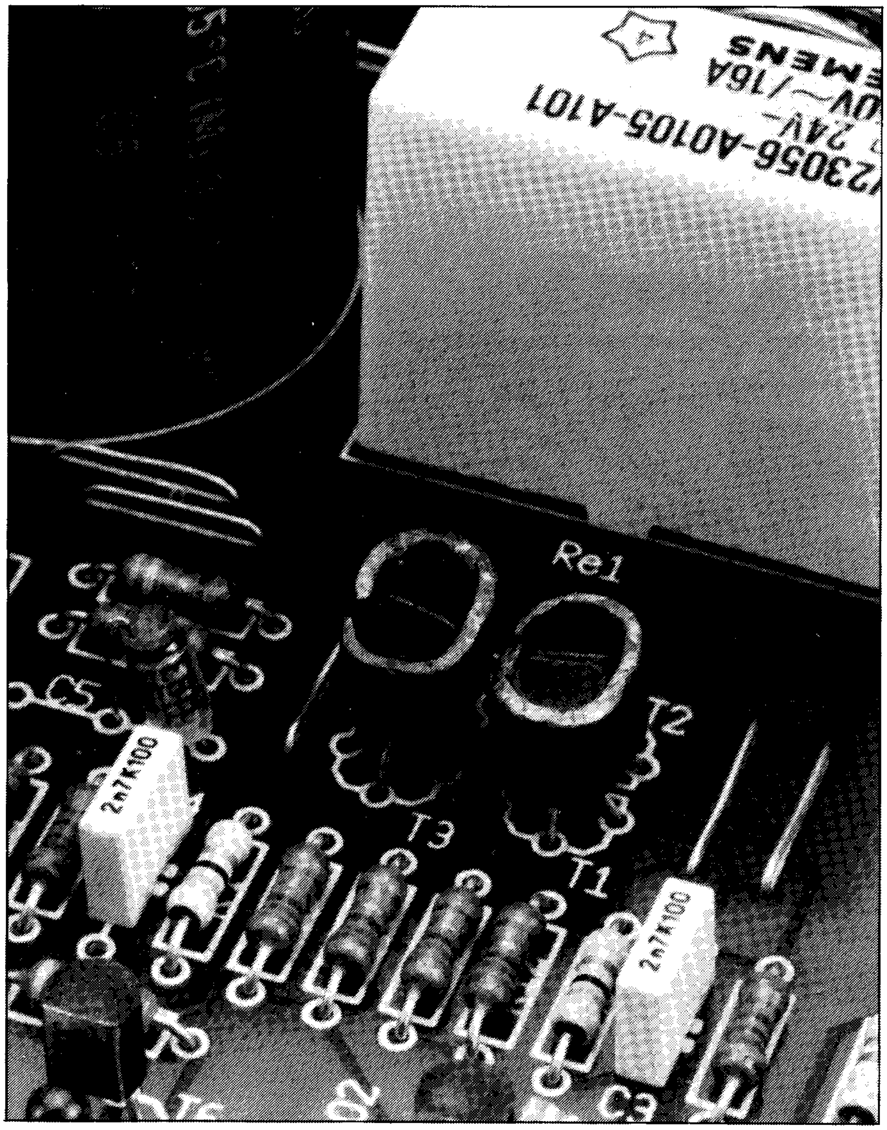


Fig. 4. The differential amplifiers are clamped together with a (DIY) copper ring.

transformers and electrolytic capacitors in a suitable enclosure. The wiring diagram for one channel is given in **Fig. 6**.

It is advisable to measure the supply voltages before they are connected to the amplifiers. Also, turn P_2 to maximum (wiper towards R_{33}) before connecting the power supply to the amplifiers. Set input presets P_1 to the centre of their travel. A few seconds after the supply has been switched on, the relay should come on. Connect a multimeter (1 V direct voltage range) and adjust P_1 until the meter reads zero (both channels!).

Switch the supply off again and insert a multimeter (1 A d.c. range) in one of the supply lines; **do not** substitute it for one of the fuses, since that would affect the operating point of the relevant power FET. Switch the supply on again, wait 5–10 minutes (when the current has stabilized) and adjust P_2 for a meter reading of 330 mA. After about half an hour, the current will remain steady at about 230 mA. The quiescent current through the output transistors is then around 200 mA. Switch off the supply, remove the meter from the supply line and repeat the above procedure with the other channel.

Finally, recheck the direct voltages at the outputs of the amplifiers and, if necessary, readjust P_1 slightly.

The loudspeakers must be 4-ohm or 8-ohm types, whose impedance must not drop below 3 Ω. It is not permissible to connect two 4-ohm units in parallel to the amplifier, because that would give problems when large drive signals are applied to the FETS.

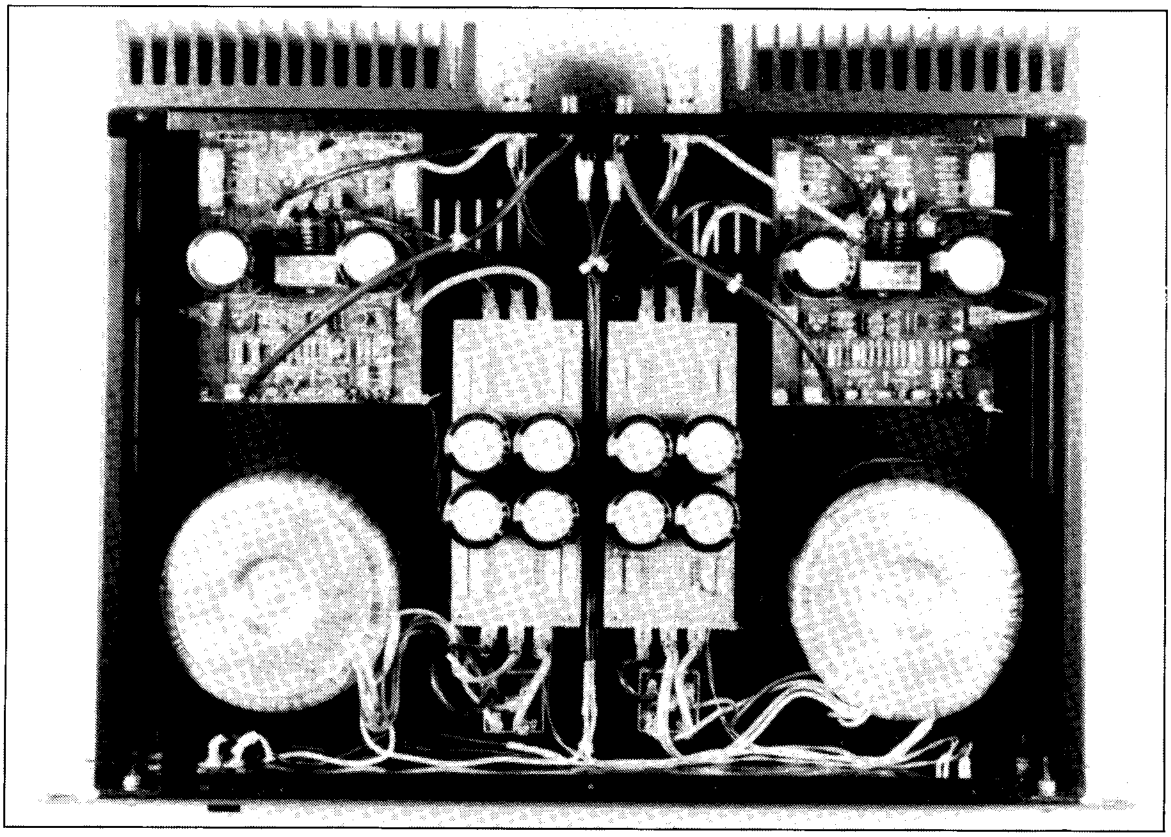


Fig. 5. Top view of the completed amplifier with the enclosure removed.

Parts list (one channel)

Resistors:

R_1 = 1 kΩ
R_2 = 47.5 kΩ, 1%
R_3, R_4 = 47 Ω
R_5 = 2.0 kΩ, 1%
R_6 = 84.5 Ω, 1%
R_7, R_8 = 10 MΩ
R_9, R_{10}, R_{13}, R_{14} = 1.21 kΩ, 1%
R_{11}, R_{12}, R_{15}, R_{16} = 22.1 Ω, 1%
R_{17}, R_{18} = 499 Ω, 1%
R_{19} = 22 kΩ
R_{20} = 2.2 kΩ
R_{21} = 560 Ω
R_{22}, R_{23} = 56.2 Ω, 1%
R_{24}, R_{27} = 150 Ω, 1%
R_{25}, R_{28} = 15.0 Ω, 1%
R_{26}, R_{29} = 15 Ω
R_{30} = 68 Ω, 5 W
R_{31} = 150 Ω, 5 W
R_{32}, R_{33} = 6.81 Ω, 0.6 W, 1%
R_{34} = 3.3 kΩ
R_{35} = 150 Ω
R_{36} = 8.2 MΩ
P_1 = 1 MΩ preset
P_2 = 1 kΩ preset

Capacitors:

C_1 = 2.2 μF, 50 V, MKT
C_2 = 1 nF
C_3, C_4 = 2.7 nF
C_5 = 330 pF, polystyrene, axial
C_6 = 33 nF
C_7, C_8 = 100 μF, 10 V, radial
C_9 = 1 μF
C_{10} = 100 nF
C_{11}, C_{12} = 10,000 μF, 50 V, radial, for PCB mounting
C_{13} = 47 μF, 40 V, radial
C_{14} = 10 μF, 63 V, radial

Inductors:

L_1 = air-core, 0.1 mH (see text)

Semiconductors:

D_1, D_2 = 3 mm LED, red (1.6 V drop at 3 mA)
D_3–D_5 = 1N4003
D_6 = 1N4148
T_1, T_2, T_6 = BC550C
T_3–T_5 = BC560C
T_7, T_9, T_{10} = BD139
T_8, T_{11} = BD140
T_{12} = IRF9540
T_{13} = IRF540
T_{14} = BC617

Miscellaneous;

Re_1 = relay, 24 V, 1 make contact (e.g., Siemens V23056-A0105-A101*)
F_1, F_2 = fuse, 2.5 A, fast, with holder for PCB mounting
Ceramic washers (5) for T_7, T_{10}–T_{13}
Terminal block (5) (see text)
Heat sink, 0.6 KW^{-1} (e.g., Fischer SK85**)
PCB No. 930102 (see p. 110)

Power supply:

Mains transformer, 2 × 25 V, 160 VA
Mains on-off switch with indicator
Fuse 1.25 A, slow with holder
Bridge rectifier Type B200C35000
Electrolytic capacitor (4), 10,000 μF, 50 V
Resistor (8) 0.1 Ω, 5 W

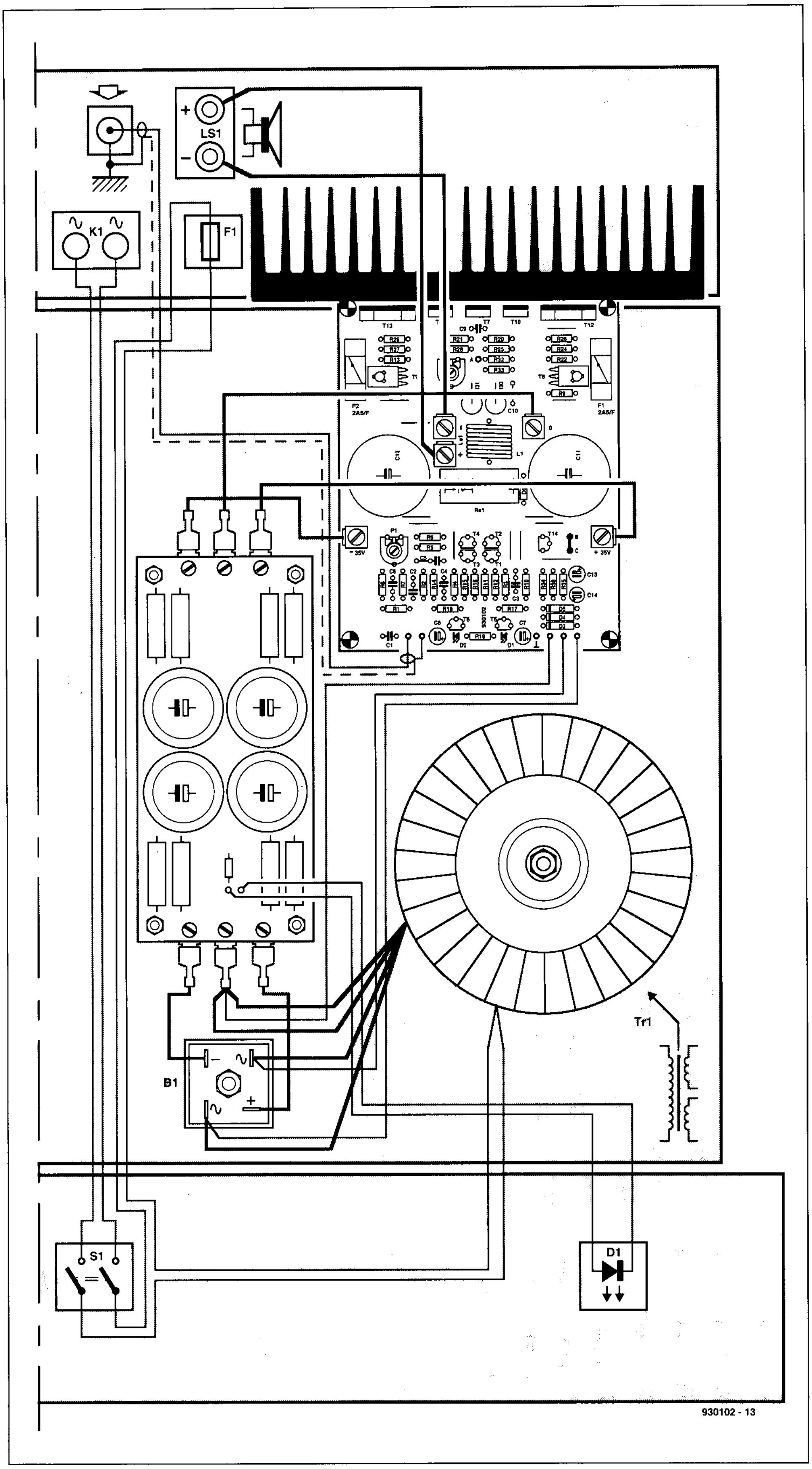


Fig. 6. Wiring diagram of one channel of the medium power HEXFET amplifier.

---

* ElectroValue, 3 Central Trading Estate, Staines, TW18 4UX, ☎ (0784) 442 253. Private customers welcome.

** Dau (UK) Ltd, 7075 Barnham Road, Barnham, West Sussex PO22 0ES. ☎ (0243) 553 031. Trade only, but information as to your nearest dealer will be given by telephone.

END

VIEWCOM

TEL 081-471 9338 TLX 929709 VICOM G FAX 081-552 0946

DIGITAL INTEGRATED CIRCUIT SPECIALIST

4000 SERIES

4000B	0.12
4000UB	0.14
4001A	0.12
4001B	0.12
4001UB	0.14
4002B	0.12
4006B	0.30
4007UB	0.14
4008B	0.31
4009AE	0.18
4009UB	0.22
4010B	0.22
4011B	0.14
4011UB	0.14
4012AE	0.12
4012B	0.14
4013B	0.17
4014B	0.30
4015B	0.30
4016B	0.18
4017B	0.26
4018B	0.28
4019B	0.20
4020AE	0.29
4020B	0.30
4021B	0.31
4022B	0.32
4023B	0.14
4023UB	0.17
4024AE	0.21
4024B	0.21
4025B	0.14
4026B	0.38
4027B	0.18
4028B	0.28
4029B	0.27
4030B	0.16
4031B	0.80
4032B	0.54
4033B	0.54
4034B	1.10
4035B	0.30
4036B	1.98
4037B	0.98
4038B	0.60
4039B	2.48
4040B	0.29
4041B	0.32
4042B	0.22
4043B	0.28
4044B	0.30
4045B	0.72
4046B	0.32
4047B	0.27
4048B	0.32
4049B	0.20
4049UB	0.20
4050B	0.20
4051B	0.25
4052B	0.25
4053B	0.25
4054B	0.52
4055B	0.48
4056B	0.36
4059B	2.98
4060B	0.30
4063B	0.28
4066B	0.22
4067B	1.42
4068B	0.14
4069UB	0.16
4070B	0.16
4071B	0.16
4072B	0.16
4073B	0.16
4075B	0.16
4076B	0.32
4077B	0.16
4078B	0.16
4081B	0.13
4082B	0.16
4085B	0.32
4086B	0.29
4089B	0.54
4093B	0.14
4094B	0.30
4095B	0.54
4096B	0.85
4097B	1.20
4098B	0.31
4099B	0.38
4104P	0.78
4106B	0.58
4160B	0.65
4161B	0.65
4163B	0.98
4174B	0.98
4175B	0.88
4194B	1.10
4409P	8.50
4410P	12.65
4411P	16.60
4412F	POA
4412FL	POA
4412VP	POA
4416P	POA
4419P	POA
4429PB	5.60
4433P	15.85
4443P	8.90
4447P	9.78
4468P	8.75
4469P	24.10
4489P	12.85
4490P	3.90
4490L	9.80
4495P	4.82
4497P	10.45
4499P	4.80
4500B	14.96
4501UB	0.27
4502B	0.34
4503B	0.30
4504B	1.37
4505B	3.40
4506U	0.88
4508B	0.72
4510B	0.26
4511B	0.32
4512B	0.30
4513B	2.60
4514B	0.72
4515B	0.72
4516B	0.30
4517B	0.92
4518B	0.27
4519B	0.28
4520B	0.28
4521B	0.60
4522B	0.72
4526B	0.40
4527B	0.38
4528B	0.40
4529B	0.44
4530B	1.48
4531B	0.88
4532B	0.44
4534B	3.98
4536B	0.98
4538B	0.44
4539B	0.62
4541B	0.32
4543B	0.44
4544B	1.62
4547B	1.78
4549B	POA
4551B	1.36
4553B	1.82
4554B	4.62
4555B	0.32
4556B	0.38
4557B	1.88
4558B	1.68
4560B	1.16
4561B	1.34
4562B	3.96
4566B	1.60
4568B	3.98
4569B	2.34
4572UB	0.30
4573P	POA
4580B	6.80
4581B	2.96
4582B	1.68
4583B	0.86
4584B	0.44
4585B	0.38
4597CP	4.40
4598B	4.40
4599B	3.42
4720B	POA
4720V	POA
4723B	POA
4724B	POA
4731VP	7.20
4737VP	17.30
4738VP	17.50
4750VD	30.20
4752VP	31.71
4753VP	POA
4754VP	POA
40085	0.94
40097	0.48
40098	0.48
40100	1.14
40101	0.76
40102	0.92
40103	0.68
40105	0.64
40106	0.30
40107	0.27
40108	POA
40109	0.50
40110	0.80
40114	1.96
40116	9.60
40117	1.66
40147	0.95
40160	0.46
40161	0.46
40162	0.46
40163	0.46
40174	0.34
40175	0.36
40181	POA
40192	0.48
40193	0.52
40194	POA
40195	0.78
40240	1.36
40244	1.36
40245	1.36
40257	1.32
40373	1.10
40374	1.10
45000P	POA
45026	3.40
45027	4.61
45028	3.45
45040	7.44
45041	7.88
45100	1.63
45106	5.40
45109	3.08
45138	1.48
45145	9.25
45146	10.44
45151	15.00
45152	16.50
45156	13.50
45157	11.06
45158	11.94
45159	18.90
45406	2.10
45407	4.98
45411	POA
45414	10.55
45428	POA
45433	POA
45440	12.75
45441	POA
45453	POA

4000 Series Surface Mount

4001BT	0.25
4002BT	0.25
4011BT	0.25
4011UBT	0.25
4012BT	0.25
4013BT	0.36
4015BT	0.67
4016BT	0.34
4017BT	0.62
4018BT	0.62
4020BT	0.76
4021BT	0.52
4023BT	0.25
4024BT	0.61
4025BT	0.25
4027BT	0.36
4028BT	0.45
4029BT	0.79
4040BT	0.65
4042BT	0.59
4046BT	1.13
4047BT	0.85
4049BT	0.85
4050BT	0.38
4051BT	0.67
4052BT	0.79
4053BT	0.86
4060BT	0.67
4066BT	0.47
4068BT	0.25
4069UBT	0.25
4070BT	0.28
4071BT	0.25
4075BT	0.25
4077BT	0.28
4078BT	0.25
4081BT	0.25
4093BT	0.36
4094BT	0.76
4508BT	1.64
4510BT	0.81
4511BT	1.08
4512BT	0.52
4514BT	1.76
4516BT	0.81
4518BT	0.94
4520BT	0.94
4521BT	0.86
4522BT	0.90
4528BT	0.70
4534BD	3.42
4538BT	0.84
4541BT	0.84
4543BT	0.82
4555BT	0.70
4556BT	0.84
4585BT	0.76
40106BT	0.42
40244BT	1.08
40373BT	1.82

74 SERIES DIL

7400	0.20
7402	0.20
7403	0.20
7404	0.25
7405	0.25
7406	0.30
7406A	0.33
7407	0.30
7407A	0.32
7408	0.23
7410	0.15
7412	0.40
7413	0.27
7414	0.28
7416	0.33
7417	0.30
7420	0.20
7425	0.15
7426	0.20
7427	0.18
7430	0.22
7432	0.27
7437	0.24
7438	0.38
7440	0.48
7442	0.38
7445	0.70
7446	0.84
7447	0.84
7447A	0.90
7451	0.25
7454	0.40
7470	0.27
7472	0.18
7473	0.23
7474	0.35
7475	0.25
7476	0.23
7480	0.79
7483	0.60
7485	0.28
7486	0.26
7490	0.39
7490A	0.72
7491	1.60
7492	0.42
7492A	0.70
7493	0.54
7493A	0.61
7495A	0.69
74104	0.42
74107	0.30
74110	4.16
74116	3.10
74118	3.95
74119	1.98
74121	0.48
74123	0.32
74125	0.37
74126	0.54
74128	0.80
74132	0.51
74150	1.36
74151	0.42
74151A	0.62
74154	1.56
74155	0.78
74157	0.43
74158	0.98
74159	3.20
74160	0.47
74161A	1.60
74163	0.80
74164	0.56
74165	0.98
74166	0.66
74174	0.68
74175	0.53
74184	2.95
74185	1.10
74192	0.72
74193	1.03
74221	1.42
74259	2.45
74265	0.80
74273	2.40
74276	2.40
74279	0.73
74283	0.68
74298	2.60
74365	0.44
74367	0.66
74393	2.05
74403	POA
74423	POA

74LS SERIES

74LS00	0.12
74LS01	0.12
74LS02	0.12
74LS03	0.12
74LS04	0.12
74LS05	0.12
74LS06	0.39
74LS07	0.39
74LS08	0.12
74LS09	0.12
74LS10	0.12
74LS11	0.12
74LS12	0.12
74LS13	0.16
74LS14	0.18
74LS15	0.12
74LS20	0.14
74LS21	0.14
74LS22	0.14
74LS24	0.33
74LS26	0.14
74LS27	0.14
74LS28	0.14
74LS30	0.14
74LS31	1.96
74LS32	0.13
74LS33	0.13
74LS37	0.14
74LS38	0.13
74LS40	0.13
74LS42	0.23
74LS44	1.62
74LS47	0.42
74LS48	0.46
74LS49	0.62
74LS51	0.12
74LS54	0.12
74LS55	0.30
74LS73	0.17
74LS73A	0.24
74LS74	0.16
74LS74A	0.18
74LS75	0.20
74LS76	0.22
74LS76A	0.24
74LS77	0.42
74LS78	0.22
74LS83	0.30
74LS83A	0.34
74LS85	0.34
74LS86	0.20
74LS90	0.24
74LS91	0.50
74LS92	0.32
74LS93	0.24
74LS95	0.38
74LS96	0.46
74LS107	0.23
74LS107A	0.28
74LS109	0.20
74LS109A	0.26
74LS112	0.20
74LS112A	0.26
74LS113	0.20
74LS113A	0.26
74LS114	0.22
74LS114A	0.26
74LS122	0.30
74LS123	0.30
74LS125	0.21
74LS125A	0.28
74LS126	0.28
74LS126A	0.28
74LS132	0.20
74LS133	0.18
74LS136	0.22
74LS137	0.62
74LS138	0.24
74LS139	0.26
74LS145	0.54
74LS147	0.86
74LS148	0.70
74LS151	0.24
74LS153	0.24
74LS154	0.70
74LS155	0.24
74LS156	0.24
74LS157	0.22
74LS158	0.24
74LS160	0.32
74LS160A	0.36
74LS161	0.32
74LS161A	0.36
74LS162	0.32
74LS162A	0.36
74LS163	0.32
74LS163A	0.36
74LS164	0.28
74LS165	0.48
74LS166	0.52
74LS168	0.58
74LS169	0.52
74LS170	0.66
74LS173	0.30
74LS173A	0.42
74LS174	0.28
74LS175	0.24
74LS181	1.40
74LS182	1.58
74LS183	1.58
74LS189A	1.88
74LS190	0.30
74LS191	0.38
74LS192	0.38
74LS193	0.38
74LS194	0.38
74LS194A	0.44
74LS195A	0.42
74LS196	0.42
74LS197	0.40
74LS221	0.38
74LS224	24.50
74LS240	0.32
74LS241	0.32
74LS242	0.32
74LS243	0.32
74LS244	0.32
74LS245	0.32
74LS247	0.34
74LS248	0.38
74LS249	0.68
74LS251	0.22
74LS253	0.34
74LS256	0.50
74LS257	0.24
74LS257A	0.34
74LS258	0.24
74LS258A	0.32
74LS259	0.48
74LS260	0.20
74LS266	0.20
74LS273	0.32
74LS275	6.10
74LS279	0.25
74LS280	0.86
74LS283	0.44
74LS290	0.24
74LS292	18.35
74LS293	0.24
74LS294	18.35
74LS295	0.58
74LS295A	0.64
74LS298	0.63
74LS299	1.18
74LS321	5.62
74LS322	1.58
74LS322A	1.64
74LS323	1.64
74LS347	1.40
74LS348	1.18
74LS352	0.84
74LS353	0.88
74LS363	1.38
74LS364	1.38
74LS365	0.21
74LS365A	0.26
74LS366	0.28
74LS366A	0.32
74LS367	0.21
74LS367A	0.30
74LS368	0.28
74LS368A	1.32
74LS373	0.32
74LS374	0.32
74LS375	0.32
74LS377	0.36
74LS378	0.62
74LS379	0.86
74LS381A	3.05
74LS385	2.22
74LS386	0.46
74LS390	0.30
74LS393	0.34
74LS395	0.36
74LS395A	0.66
74LS396	1.68
74LS398	1.22
74LS399	0.62
74LS423	1.82
74LS445	1.88
74LS450	5.60
74LS461	4.45
74LS461A	5.40
74LS465	3.82
74LS467	3.82
74LS468	3.82
74LS469	5.62
74LS469A	6.70
74LS490	0.90
74LS491A	5.98
74LS502	2.60
74LS540	0.93
74LS541	0.76
74LS546	4.43
74LS548	4.18
74LS549	4.18
74LS568	1.62
74LS569	1.14
74LS573	1.34
74LS574	1.34
74LS590	4.53
74LS591	6.58
74LS592	5.28
74LS593	6.25
74LS595	3.76
74LS597	4.64
74LS604	4.46
74LS605	4.46
74LS606	4.46
74LS610	9.95
74LS611	11.94
74LS612	6.68
74LS620	1.38
74LS621	1.76
74LS622	1.66
74LS623	1.28
74LS624	2.10
74LS625	2.28
74LS626	2.18
74LS627	2.33
74LS628	2.18
74LS629	0.93
74LS631	42.20
74LS640	0.84
74LS641	0.86
74LS641-1	1.28
74LS642	0.82
74LS642-1	2.48
74LS643	0.84
74LS643-1	2.48
74LS644	0.84
74LS644-1	2.48
74LS645	0.86
74LS645-1	1.28
74LS646	7.62
74LS647	6.68
74LS648	6.68
74LS649	6.68
74LS651	6.30
74LS652	6.94
74LS653	5.58
74LS654	5.58
74LS668	0.83
74LS669	0.56
74LS670	0.68
74LS673	28.46
74LS674	17.60
74LS682	2.62
74LS683	2.85
74LS684	3.85
74LS685	2.82
74LS686	3.64
74LS687	2.42
74LS688	1.68
74LS689	2.45
74LS693	4.90
74LS697	15.84
74LS716	6.58
74LS718	6.58
74LS724	1.24
74LS748	1.15
74LS794	8.86
74LS795	2.34
74LS796	2.34
74LS797	2.34
74LS848	3.20

74HC SERIES

74HC00	0.13
74HC02	0.13
74HC03	0.13
74HC04	0.15
74HCU04	0.19
74HC05	0.14
74HC08	0.17
74HC10	0.19
74HC11	0.13
74HC14	0.24
74HC14A	0.28
74HC20	0.18
74HC21	0.19
74HC27	0.19
74HC30	0.19
74HC32	0.19
74HC42	0.29
74HC51	0.19
74HC58	0.28
74HC73	0.23
74HC74	0.23
74HC75	0.27
74HC76	0.27
74HC77	0.34
74HC85	0.32
74HC86	0.24
74HC107	0.26
74HC109	0.24
74HC112	0.27
74HC113	0.27
74HC123	0.34
74HC125	0.31
74HC126	0.32
74HC131	0.35
74HC132	0.27
74HC133	0.31
74HC137	0.44
74HC138	0.32
74HC139	0.21
74HC141	0.41
74HC147	0.41
74HC148	0.37
74HC151	0.31
74HC153	0.31
74HC154	0.89
74HC155	0.47
74HC157	0.33
74HC158	0.32
74HC160	0.43
74HC161	0.38
74HC162	0.43
74HC163	0.43
74HC164	0.38
74HC165	0.55
74HC166	0.59
74HC173	0.51
74HC174	0.32
74HC175	0.32
74HC181	1.30
74HC182	0.40
74HC190	0.45
74HC191	0.48
74HC192	0.52
74HC193	0.40
74HC194	0.45
74HC195	0.32
74HC221	0.41
74HC237	0.49
74HC238	0.50
74HC240	0.44
74HC241	0.44
74HC242	0.54
74HC243	0.59
74HC244	0.43
74HC245	0.44
74HC251	0.24
74HC253	0.35
74HC257	0.32
74HC258	0.49
74HC259	0.44
74HC266	0.32
74HC273	0.41
74HC279	0.34
74HC280	0.60
74HC283	0.38
74HC298	0.49
74HC299	1.04
74HC323	1.07
74HC354	0.37
74HC356	0.44
74HC365	0.33
74HC366	0.35
74HC367	0.32
74HC368	0.35
74HC373	0.41
74HC374	0.38
74HC375	0.51
74HC377	0.51
74HC386	0.19
74HC390	0.36
74HC393	0.41
74HC423	0.64
74HC521	0.64
74HC533	0.64
74HC534	0.60
74HC540	0.69
74HC541	0.58
74HC563	0.59
74HC564	0.59
74HC573	0.64
74HC573A	0.68
74HC574	0.64
74HC589	1.10
74HC590	0.80
74HC592	0.80
74HC593	1.12
74HC595	0.84
74HC597	0.79
74HC620	1.09
74HC623	1.09
74HC633	1.09
74HC640	0.89
74HC643	0.89
74HC645	0.94
74HC646	1.19
74HC648	1.19
74HC651	0.99
74HC652	0.99
74HC658	3.02
74HC659	3.02
74HC664	3.02
74HC665	3.02
74HC670	0.74
74HC677	2.55
74HC678	3.98
74HC680	2.58
74HC682	2.84
74HC684	3.84
74HC688	0.79
74HC690	1.09
74HC691	1.09
74HC692	1.16
74HC693	1.16
74HC696	POA
74HC697	1.06
74HC698	1.06
74HC699	1.06
74HC4002	0.24
74HC4015	0.72
74HC4016	0.43
74HC4017	0.30
74HC4020	0.49
74HC4022	0.38
74HC4024	0.33
74HC4028	0.39
74HC4040	0.33
74HC4046	1.30
74HC4049	0.37
74HC4050	0.36
74HC4051	0.64
74HC4052	0.74
74HC4053	0.68
74HC4053A	0.74
74HC4060	0.32
74HC4061	1.70
74HC4066	0.31
74HC4066A	0.36
74HC4072	0.30
74HC4075	0.25
74HC4078	0.31
74HC4094	0.49
74HC4316	0.68
74HC4351	0.89
74HC4511	0.55
74HC4514	1.19
74HC4515	1.19
74HC4518	0.54
74HC4520	0.59
74HC4538	0.74
74HC4543	0.55
74HC7001	0.68
74HC7002	0.68
74HC7032	0.68
74HC7266	0.56
74HC7074	1.34
74HC7292	0.77
74HC7294	0.77
74HC40102	0.84
74HC40103	0.84
74HC40105	1.40

74HCT SERIES

74HCT00	0.22
74HCT02	0.22
74HCT03	0.22
74HCT04	0.22
74HCT08	0.22
74HCT10	0.22
74HCT11	0.22
74HCT14	0.26
74HCT20	0.26
74HCT21	0.26
74HCT27	0.22
74HCT30	0.22
74HCT32	0.22
74HCT42	0.46
74HCT73	0.36
74HCT74	0.26
74HCT75	0.36
74HCT85	0.60
74HCT86	0.36
74HCT93	0.58
74HCT107	0.40
74HCT109	0.42
74HCT112	0.42
74HCT123	0.64
74HCT125	0.56
74HCT126	0.56
74HCT132	0.50
74HCT137	0.52
74HCT138	0.32
74HCT139	0.45
74HCT147	0.54
74HCT151	0.52
74HCT153	0.44
74HCT154	1.18
74HCT157	0.44
74HCT158	0.44
74HCT160	0.56
74HCT161	0.56
74HCT162	0.56
74HCT163	0.56
74HCT164	0.52
74HCT165	0.52
74HCT166	0.52
74HCT173	0.52
74HCT174	0.52
74HCT175	0.52
74HCT181	2.48
74HCT182	0.96
74HCT190	0.64
74HCT191	0.64
74HCT192	0.64
74HCT193	0.64
74HCT194	0.76
74HCT195	0.78
74HCT221	0.98
74HCT237	0.94
74HCT238	0.51
74HCT240	0.44
74HCT241	0.44
74HCT242	0.76
74HCT243	0.64
74HCT244	0.44
74HCT245	0.44
74HCT251	0.58
74HCT253	0.34
74HCT257	0.48
74HCT258	0.48
74HCT259	0.78
74HCT273	0.68
74HCT280	0.98
74HCT283	0.96
74HCT299	1.64
74HCT354	0.86
74HCT356	0.86
74HCT365	0.54
74HCT366	0.54
74HCT367	0.54
74HCT368	0.54
74HCT373	0.44
74HCT374	0.44
74HCT377	0.64
74HCT390	0.68
74HCT393	0.68
74HCT394	0.98
74HCT521A	1.10
74HCT533	0.68
74HCT534	0.64
74HCT540	0.64
74HCT541	0.64
74HCT563	0.66
74HCT564	0.66
74HCT573	0.64
74HCT574	0.64
74HCT583	1.26
74HCT640	0.90
74HCT643	0.90
74HCT645	0.75
74HCT646	1.28
74HCT648	1.28
74HCT651	1.10
74HCT652	POA
74HCT670	1.10
74HCT673	1.10
74HCT688	1.10
74HCT4002	0.26
74HCT4015	0.76
74HCT4016	0.52
74HCT4017	0.68
74HCT4020	0.74
74HCT4024	0.68
74HCT4040	0.70
74HCT4046	2.10
74HCT4051	0.84
74HCT4052	0.84
74HCT4053	0.84
74HCT4060	0.84
74HCT4066	0.66
74HCT4067	3.32
74HCT4075	0.36
74HCT4094	0.84
74HCT4316	0.68
74HCT4351	1.04
74HCT4510	1.04
74HCT4511	0.94
74HCT4514	1.64
74HCT4515	1.68
74HCT4516	1.08
74HCT4520	0.90
74HCT4538	1.02
74HCT7007	0.26
74HCT7046	2.80
74HCT40102	1.64
74HCT40103	1.48
74HCT40104	1.82
74HCT40105	1.40

74HC SERIES SURFACE MOUNT

74HC00M	0.21
74HC02M	0.21
74HC03M	0.21
74HC04M	0.21
74HCU04	0.21
74HC08M	0.21
74HC10M	0.21
74HC14M	0.34
74HC20M	0.21
74HC30M	0.21
74HC32M	0.21
74HC74A	0.27
74HC75M	0.29
74HC85WM	0.65
74HC86M	0.34
74HC123AM	0.42
74HC125M	0.46
74HC132M	0.42
74HC138M	0.34
74HC139M	0.34
74HC154WM	0.48
74HC157M	0.34
74HC161M	0.42
74HC164M	0.46
74HC165M	0.57
74HC173M	0.44
74HC174M	0.38
74HC221AM	0.65
74HC240WM	0.55
74HC244WM	0.55
74HC245AW	0.61
74HC251M	0.34
74HC259M	0.69
74HC273WM	0.55
74HC367WM	0.53
74HC373WM	0.55
74HC374WM	0.55
74HC390M	0.57
74HC393M	0.53
74HC540WM	0.76
74HC541WM	0.76
74HC573WM	1.09
74HC574WM	0.84
74HC688WM	0.84
74HC4017M	0.44
74HC4020M	0.44

74F SERIES

74F00	0.28
74F02	0.28
74F04	0.28
74F06	0.74
74F07	0.74
74F08	0.28
74F10	0.28
74F11	0.28
74F13	0.62
74F14	0.41
74F20	0.28
74F27	0.28
74F30	0.28
74F32	0.28
74F37	0.41
74F38	0.44
74F40	0.66
74F51	0.44
74F64	0.32
74F74	0.30
74F85	2.36
74F86	0.41
74F109	0.42
74F112	0.72
74F113	1.12
74F114	1.12
74F125	0.60
74F126	0.88
74F132	0.52
74F138	0.58
74F139	0.52
74F148	0.90
74F151	0.52
74F153	0.62
74F157	0.54
74F158	0.54
74F160	1.28
74F160A	1.29
74F161	1.28
74F162	1.28
74F163	1.28
74F164	1.28
74F166	4.32
74F168	3.40
74F169	3.40
74F174	0.76
74F175	0.76
74F181	3.36
74F182	1.22
74F189	4.36
74F190	2.92
74F191	2.92
74F192	2.92
74F193	2.92
74F194	1.31
74F195	2.90
74F219	4.38
74F224	1.92
74F240	0.62
74F241	0.62
74F244	0.62
74F245	0.72
74F251	0.62
74F251A	0.66
74F253	0.62
74F257	0.62
74F257A	0.66
74F258	0.62
74F259	3.72
74F260	0.80
74F269	8.28
74F273	2.20
74F280	0.62
74F283	0.78
74F299	3.36
74F323	4.48
74F350	1.50
74F352	0.64
74F353	1.14
74F365	1.28
74F366	1.30
74F367	1.38
74F368	1.30
74F373	0.62
74F374	0.62
74F378	1.56
74F381	3.68
74F385	11.18
74F395	3.28
74F399	0.98
74F412	5.02
74F413	19.66
74F432	4.48
74F521	1.20
74F524	7.26
74F533	1.20
74F534	1.20
74F537	1.60
74F538	1.60
74F539	1.60
74F540	1.78
74F541	1.76
74F543	4.92
74F544	4.92
74F545	3.36
74F547	6.04
74F563	2.24
74F564	2.24
74F573	1.60
74F574	1.60
74F579	6.64
74F604	5.08
74F620	3.98
74F621	3.52
74F623	3.98
74F646	5.35
74F646	5.15
74F676	10.60
74F821	3.98
74F823	3.98
74F825	3.98
74F827	3.98
74F828	4.48
74F841	4.48
74F843	4.30
74F845	4.30
74F1242	2.41
74F1243	2.41
74F1244	2.12

74AC SERIES

74AC00	0.38
74AC02	0.49
74AC04	0.49
74AC08	0.49
74AC10	0.49
74AC11	0.49
74AC14	0.49
74AC20	0.49
74AC32	0.49
74AC74	0.49
74AC109	0.61
74AC138	0.68
74AC139	0.65
74AC151	0.68
74AC153	0.65
74AC157	0.65
74AC158	0.65
74AC163	0.72
74AC169	1.71
74AC174	0.65
74AC175	0.80
74AC191	1.12
74AC240	0.86
74AC241	0.88
74AC244	0.88
74AC245	1.10
74AC251	0.60
74AC253	0.60
74AC258	0.60
74AC273	1.10
74AC299	2.06
74AC373	0.88
74AC374	0.88
74AC377	0.84
74AC540	0.98
74AC541	0.98
74AC573	1.26
74AC646	3.86
74AC648	3.86

74C SERIES

74C00	0.56
74C02	0.56
74C08	0.56
74C10	0.56
74C14	0.56
74C20	0.98
74C30	0.98
74C32	0.68
74C42	0.98
74C48	1.98
74C73	1.15
74C74	0.68
74C76	1.15
74C85	1.52
74C90	1.25
74C93	2.10
74C95	1.60
74C150	6.10
74C151	4.16
74C154	2.98
74C157	2.48
74C164	1.52
74C165	1.23
74C221	1.54
74C240	2.08
74C244	2.08
74C373	2.08
74C374	2.08
74C901	0.86
74C902	0.86
74C903	1.52
74C906	0.86
74C907	1.52
74C908	2.80
74C911	14.42
74C912	8.30
74C914	1.16
74C915	2.74
74C922	4.35
74C923	4.35
74C925	9.30
74C926	9.30
74C929	9.30

74S SERIES

74S00	0.44
74S02	0.44
74S03	0.51
74S04	0.42
74S08	0.42
74S09	0.48
74S10	0.98
74S11	0.48
74S20	0.48
74S32	0.78
74S40	0.25
74S51	0.36
74S64	0.36
74S74	0.98
74S86	1.12
74S112	1.08
74S124	2.42
74S132	0.98
74S133	0.73
74S134	1.95
74S138	0.88
74S139	0.88
74S140	0.78
74S153	1.26
74S157	1.72
74S163	2.60
74S174	0.92
74S175	1.35
74S182	3.29
74S189	2.14
74S195	2.40
74S240	1.00
74S241	1.12
74S244	1.77
74S257	1.22
74S258	1.22
74S260	0.70
74S273	2.44
74S274	2.42
74S280	0.96
74S283	1.90
74S374	2.18
74S394	2.10
74S412	2.10
74S436	2.62
74S437	2.62
74S472	2.32
74S734	2.62

VOLTAGE REGULATORS

78008AP	1.15
7805	0.28
7805A	0.32
7805FA	0.45
7806	0.28
7808	0.28
7809	0.32
7812	0.28
7812A	0.32
7812CTC	0.32
7815	0.28
7818	0.28
7824	0.28
78L05	0.24
78L05A	0.28
78L05ACLP	0.40
78L05ACZ	0.28
78L12	0.28
78L12A	0.28
78L12ACZ	0.30
78L15	0.28
78L24	0.28
78L56	1.10
78M05	0.32
78M05A	0.36
78M12	0.32
78M12A	0.36
78M13A	0.65
78M15	0.32
78S05	0.48
78S12	0.48
78S15	0.55
7905	0.28
7905A	0.32
7905FA	0.60
7909	0.55
7912	0.30
7912A	0.36
7912FA	0.78
7915	0.30
7918	0.30
7924	0.30
79L12A	0.35
79L12ACP	0.35
79M05	0.42
79M05A	0.42
79M05FA	0.65
79M12	0.50
79M12A	0.60
LM317T	0.50
LM317MP	1.06
LM317LZ	0.55
LM338K	4.45
UA78GU1C	1.02
UA79GU1C	1.02
RC4195N	1.80

DIODES

1N2986RB	18.20
1N3881	2.54
1N3997A	6.55
1N4001	0.04
1N4002	0.04
1N4003	0.04
1N4006	0.04
1N4007	0.04
1N4148	0.03
1N4149	0.06
1N4150	0.08
1N4446	0.06
1N4728A	0.24
1N4735A	0.24
1N4736A	0.24
1N4740A	0.24
1N4743A	0.24
1N4744A	0.24
1N4756A	0.24
1N5226B	0.09
1N5232B	0.09
1N5234B	0.09
1N5337B	0.48
1N5349B	0.48
1N5352B	0.48
1N5357B	0.48
1N5365B	0.48
1N5366B	0.48
1N5370B	0.48
1N5380B	0.48
1N5401	0.11
1N5402	0.11
1N6287A	1.55
1N825	1.80
1N825A	1.34
1N827	1.40
1SS252	0.20
5082-2800	0.66
5082-2810	1.40
5082-2835	0.44
AA119	0.60
AA144	0.72
AAZ15	0.58
AAZ17	0.58
AAZ18	0.48
BAV10	0.08
BAV45	4.98
BAW62	0.06
BAX16	0.06
BB204	0.32
BB212	2.48
BB405B	0.22
BB809	0.60
BY179	0.42
BY260-200	3.58
BY261-200	3.98
BYV28-100	0.99
BYV32-50	1.60
CV8805	0.60
DS16C	0.40
MV1404	15.90
MV209	1.20
OA200	0.10
OA202	0.20
OA47	0.14
OA90	0.14
P6KE36A	0.88
P6KE47A	0.88
REC53A	0.40
ZPD2.7V	0.06

ZENER DIODES MISC.

BZY93C7V5	2.66
BZY93C15	2.66
BZY93C18R	2.66
BZY93C20	2.66
BZY93C24V	2.66
BZY93C33R	2.66
BZT03C120	0.40
BZX61C9V2	0.09
BZX61C24V	0.09

ZENER DIODES 400mW
2.4V to 75V
Price: 6p each

ZENER DIODES 500mW
2.4V to 200V
Price: 6p each

ZENER DIODES 1.3 WATT
2.7V to 200V
Price:10p each

ZENER DIODES 3.0 WATT
7.5V to 270V
Price:40p each

ZENER DIODES 5.0 WATT
3.3V to 200V
Price:42p each

ZENER DIODES STUD MOUNT 20 WATT
7.5V to 75V
Price: £4.94 ea.

BRIDGE RECTIFIERS

0.9A/200VDIL	0.38
3.0A/200V SIL	0.57
6A/100V SIL	1.60
8A/200V SIL	1.96
35A/100V Sqr	2.98
KBPC1002	1.64
KBPC3502	2.98
W005- 1A/50V	0.32
W02G- 1.5A	0.40
2W02	0.40
2KBB10R/SIL	0.66
2KBB20R/SIL	0.70
B80C1500/Sq	0.35
B80C1500SIL	0.60
SKB6008/60A	POA

CRYSTALS

HC49(HC18/U)

Freq.MHz	
1.843200	1.60
2.000000	1.66
2.457600	1.49
3.276800	0.98
3.579545	1.10
3.686400	1.02
4.000000	1.02
4.096000	1.10
4.194304	1.10
4.433619	1.10
4.608000	1.10
4.915200	1.20
5.000000/S	1.02
5.068800	1.10
5.242880	1.20
5.888200	1.80
6.000000	1.02
6.144000	1.02
6.400000	1.64
6.552000	1.40
6.553600	1.21
7.372800	0.78
8.000000	1.00
8.867230	1.34
9.830400	1.20
10.00000	1.10
10.69500	1.90
11.00000	1.10
12.00000	0.92
13.87500	2.40
14.00000	1.64
14.31818/S	0.85
14.74560/S	1.10
14.74560	1.10
15.00000/S	1.10
16.00000	1.02
16.00000/S	1.20
18.43200/S	1.10
19.66080/S	1.20
20.00000/S	1.60
22.11840/S	1.68
24.00000/S	1.82
27.64800/S	1.20
30.00000/S	6.99
32.00000/S	1.40
48.00000/S	1.68

S = Series

HC33/U

0.204800	8.23
0.307200	6.99
1.000000	3.95
1.843200	3.71
2.000000	4.65
2.097152	3.71
2.457600	1.92
2.500000	1.92
3.000000	2.25

HC49/U4H

3.276800	1.66
3.579545	1.58
5.068800	2.25
7.864320	1.49
8.000000	1.14
10.00000	2.25
11.05920	2.40
12.00000	1.14
14.00000	2.25
16.00000	1.14
20.00000	1.52
24.00000	1.90

UM-1

8.000000	2.25
8.192000	2.02
10.00000	2.25
11.00000	2.25
12.28800	2.66
15.00000	2.25
17.73447	2.80
18.00000	2.50
20.00000	2.25
21.00000	2.25
24.00000	2.80

CRYSTALS MISC.

HC43/T	
1.000000	6.99
MINI CYLINDER	
0.032768	0.88
WATCH	
0.032768	0.82

CRYSTAL OSC. MODULES

8pin DIL Plastic pkg TTL Output
4 Pins spaced at corners of 8pinDIL
Freq.= MHz
4, 4.9152, 8, 10, 12. 16 & 20
Price: £2.98 ea.
24, 32, 40 & 50MHz
Price £3.40 ea.

8pin DIL Sealed Metal Package HCMOS Output
13.2mm sq.
Pins spaced at corners of 8pinDIL
Freq.= MHz
3.6864,4,8,10,12,16, 20,24,32,40 & 50
Price: £4.20 each

TTL Output 14pin DIL Layout Sealed Metal 4pin Pkg
Freq.= MHz
1MHz **£8.90 ea.**

4,4.9152,6,8,9.8304, 10,12,15,16, 18.432, 19.6608, 20, 24, 25 & 30MHz
Price: £3.52 ea.

30, 32, 32.768, 33.33, 40 & 50MHz
Price: £4.45 ea.

Programmable Crystal Oscillators

EXO-3C SERIES 8pin DIL Plastic Package
Freq.= MHz
12, 14.31818, 16, 16.384,19.6608 & 20MHz
Price: £3.92 ea.

16pin DIL Plastic Package
Programmable for 57 Diff.Frequency

SPG8640AN
0.005 to 600kHz

SPG8640BN
0.0083 to 1MHz

SPG8640CN
0.064 to 768kHz

SPG8650BN
0.00083 to 100kHz

Price: £ 9.25 ea.

DC to DC Converters

TDK CE-0344	5.60
3W5R 15-15	27.50
IPL S.010	23.40

1 Watt DC/DC 5V Input ±Output DIL & SIL by Newport
NMA0505±5V
NMA0509±9V
NMA0512±12V
NMA0515±15V
Price:£7.90ea.

DC/DC Converters by Computer Products

PM623	24.60
PM671	26.70
PM672	26.70
PM903	44.00
PM951	46.50

RESISTORS

METAL FILM 0.25W 1%
E24 Series
10R to 1M 3p each
N.B. Min Qty. Order Min. 5pcs per value

METAL FILM PRECISION 0.25 WATT 0.1%
E96 Series
100R to 255K
Price: £0.94 each

HIGH PRECISION NON-INDUCTIVE WIRE WOUND 0.15 WATT 0.1%
Temp.Coeff.3ppm
10R,50R,100R,250R, 10K,100K
Price: £3.85 each

HIGH PRECISION NON-INDUCTIVE WIRE WOUND 0.33 WATT 0.1%
Temp.Coeff.3ppm
1R,5R,10R,20R,50R
Price: £3.60 each

100R,120R, 250R, 500R,1K, 2K, 5K, 10K,20K
Price: £3.10 each

MEMORIES

DYNAMIC RAM

4164-10	1.20
4164-12	1.00
4164-15	1.00
41256-8	1.60
41256-10	1.50
41256-12	1.40
41464-12	4.45
41464-10	4.45
4464-10	2.80
414256A-70	3.90
44C256AZ-10	6.95
44C256-8	5.00
511000-85	8.45
HM48416AP-15	4.60
HM48416AP-20	4.25
HY53C256LS-80	1.60
HY53C464LS-80	3.95
HYB511000-85	8.45
KM44C256AZ10	6.95
M5M4464P-15	4.60
MK4116N-54	2.80
MK4564N-15	1.00
NMC3764N-15	1.60
UPD41464C-12	4.20
UPD41464C-15	4.20
UPD416C-2	3.40
UPD416C-3	3.65
UPD446D-1	2.60

STATIC RAM

2114-3L	3.40
6264LP-10	2.40
6264LP-12	2.40
62256LP-12	4.95
62256LP-10	4.95
CDM6116AE3	5.30
CDM6117AE3	5.85
HM1-6116-5	4.38
HM3-6116-5	3.60
HM6116LP-2	2.60
HM6116LP-3	2.60
HM6117LP-3	5.75
HM62256LP-10	7.93
HM6264ALP-12	3.95
HM6264ASP-20	3.95
HM6267P-35	5.07
HM628128LP-80	18.55
HM66204L-12	15.80
KM62256ALP-10	4.60
LH5164D-10L	2.40
P2114AL-2	3.40
P2114AL-4	3.40
PCD5101P	3.30
UPD43256AGU10L	8.33
UPD43256C-12	5.60
UPD4364C-15	4.70

UVPROMS

27C128-25	2.95
27C64A-15	2.74
27C256-15	3.95
27C256-25	3.95
D27256	5.40
HM27C101G-20	9.80
HN27C1024HG10	16.63
HN27C64FP-20T	3.40
HN27C64G-15	4.20
HN27C64G-20	4.20
HN462532P	4.50
HN4827128G-25	4.55
HN482764G	3.80
HY6264LP-10	2.40
M2716-1F1	3.50
M5L2732K	4.40
M5L2764K	3.30
MBM27C64-20/21V	4.90
MBM27C128-30	4.20
MBM27C256-30	5.10
NMC27C256Q-25	4.95
NMC27C64Q-25	3.66
TMS2516JL-45	4.58
TMS27128JL-25	4.60
TMS2716JL-45	4.60
UPD27256D/21V	5.60
UPD2732A/21V	4.95
UPD27C256D-15	5.80
UPD27C512D-15	6.96
UPD27C64D-25	4.95

EEPROMS

AT28C256-15DC	28.50
AT28C64-25	9.80
AT28C64-15	10.95
KM28C256-20	25.84
KM28C256-15	27.50
KM28C64-25	9.20
X2816AD	5.10
X2816AP-25	5.10
X2864AP-35	12.20

MISC. MEMORIES

6341-1J	4.58
AM2148-45DC	5.44
AM27S281PC	3.98
IDT7130LA-100P	10.43
IDT7132LA-100P	11.19
MB8414E	4.95
MCM4027AC3	2.80
N82S126AN	2.49
N82S153N	5.80
N82S181AN	6.09
NMC6504J-9	3.40
NMC9306N	1.45
P5101L-1	3.90
TBP18S030N	1.74
TBP24S10N	2.90
TBP24SA10N	3.15
TC5501P	3.50
TC5504AP-2	3.40
TC5516PL-15	4.20
TC5517AP-2	4.20
TC5565PL-15	3.60
TMS4014JDL	3.40

CAPACITORS SURFACE MOUNT

Multilayer Ceramic
63 VOLT
Case Size: 1206
L2xW1.25mm

10pF 22pF 33pF 47pF
100pF 220pF 330pF
470pF 1000pF 2200pf
3300pF 4700pF 10000,
22000pF 33000pF
Price: 15p each

47000pF 100000pF
Price: 18p each

MICROPROCESSOR & SUPPORT ICs

100114DEC	7.40
100141DC	9.80
6321P	4.20
63485CP32/sm	19.95
63B03XP	10.07
6502	2.94
6502A	3.90
6520P	4.40
6522	4.40
6522A	5.26
6551	4.43
6551A	4.43
65C02P2	5.84
65C02P3	6.98
65C102P2	7.00
65C22P2	4.80
65C51E-1	3.80
65C51E-2	4.38
68000P-10/12	POA
68000P-16	POA
68000P-8	4.95
68008P-8	POA
68010P-12	POA
6802P	2.95
6803AP	4.98
6805E3E	9.18
6810P	4.35
6821P	1.52
6840P	2.20
6844P	17.20
6845P	4.86
6845SP	5.40
68A00P	7.02
68A09P	7.62
68A21P	3.03
68A40P	2.36
68A50P	2.82
68B09P	3.98
68B21P	1.98
68B40P	2.98
8080A	4.96
8085AH-2	5.98
8086	3.40
8086-2	3.90
80C286-12/pga	48.50
80C286-8/plcc	24.40
80C85A	4.95
80C85A-2	5.94
8118-5CH	7.60
93C46A	4.67
93C46N	4.40
93L34DC	7.08
AM25LS2568P	2.68
AM25LS2569P	2.68
AM2602PC	2.30
AM26LS31DC	2.30
AM26LS31PC	1.26
AM27S191ADC	10.20
AM27S281PC	6.25
AM2964BDC	12.36
AM2965DC	6.36
AM2966PC	3.98
AM29826DC	3.34
AM685DL	9.82
AM8238PC	5.60
AM9050CDC	4.95
AM9050CPC	4.60
AM9102CPC	2.82
AM9114BDM	9.96
AM9551PC	9.66
AM96L02PC	3.35
AY-5-8136	6.45
AY-5-8136-006	6.45
C1164/SMD	4.98
C8231A	59.00
C8253	3.60
CA80C85B	5.98
CD82C85	9.62
CD82C86H-5	9.74
CG80C286-12	48.50
CG80C286-16	65.00
COM8136	6.45
COM81C17	8.15
CP82C54	6.42
CRT-8004-001	9.65
CS8205	8.92
D3232	5.60
D8086	5.48
D8086-2	8.80
D8202A	POA
D8254-2	6.42
D8284A	3.90
D8288	6.48
D82C284-12	9.60
D82C284-8	7.85
D82C288-10	10.96
D82C288-12	11.85
D82C288-8	9.36
D8748H	9.95
DM9601N	2.45
DP8228N	6.36
DP8238N	6.36
DP8304BN	2.34
DP8311N	6.54
DS1221	6.44
DS1231-20	4.44
DS1232	3.26
DS3486N	3.20
DS3487N	3.20
DS34C86N	4.80
DS34C87N	4.80
DS3631N	3.33
DS3632N	2.81
DS3633N	3.33
DS3634N	2.81
DS3691N	4.96
DS3862N	7.38
DS5000-32-12	47.50
DS8640N	1.20
DS8820AN	2.95
DS8832N	2.68
DS8836N	2.44
DS8837N	2.40
DS8838N	2.40
EF6803A-1P	3.80
EF6803P	3.80
EF6821P	1.30
EF68B09P	3.18
EF68B21P	1.44
EP610PC-35	POA
HD1-0165-5	10.96
HD146818AP	4.20
HD3-6402-9	6.16
HD3-6440-9	8.89
HD3-6495-9	8.89
HD44883	9.52
HD46505SP	9.85
HD46802P	5.50
HD6321P	4.20
HD63485PS32	32.50
HD63B03XP	11.95
HD68000-8	11.59
HD6845SP	6.92
HD68A52P	5.60
HD68B21P	4.29
HI3-7159-5	20.98
HI3-7159A-5	23.40
HM10422	14.30
ID82C86H	17.06
IM6402AIPL	7.09
IM6402IPL	3.73
IM6403IPL	POA
IMS2600P-15	4.40
INS8250N	7.80
INS8250N-B	7.80
M5M82C51AP	4.20
M5M82C54P-6	5.40
MAB8031AH12P	4.56
MAB8035HL-6P	5.98
MC10103P	1.98
MC10115L	3.21
MC10115P	1.98
MC146805E2P	9.18
MC68000P12/16	POA
MC68010P10/12	POA
MC6802P	2.47
MC6809P	6.78
MC6821P	1.80
MC6840P	5.05
MC6844P	18.40
MC6845P	7.38
MC6850P	3.35
MC68705R3P	25.35
MC68A00P	7.02
MC68A09P	7.62
MC8314P	6.60
MCM6810P	3.00
MCM68A10P	5.35
MM53200N	3.40
MM58167BN	10.64
MM58174AN	14.80
MM58274CN	9.18
MSM5832RS	3.39
MSM80C35RS	4.90
MSM80C39/SMD	6.45
MSM80C85A	3.95
MSM80C85A-2	5.98
MSM80C86	7.60
MSM81C55	4.60
MSM82C51A	3.58
MSM82C53-2	3.98
MSM82C53-5	3.58
MSM82C54-2	4.20
MSM82C59A-2	3.98
MSM82C84A	3.30
MSM82C84A-2	3.60
MSM82C88	12.60
N80C286-10/pl	24.50
N80C286-12/pl	29.54
N80L286-8C2/pl	36.20
N8235N	3.68
N8264N	3.68
N82S126AN	3.25
N82S181F	10.04
NS16450N	4.68
NS16550AFN	12.60
NSC800N-1	10.80
P8032AH	4.29
P8051AH	11.20
P8052AH/Basic	23.45
P8080A	3.90
P8085A-2	5.98
P8085AH-2	5.98
P8088	4.80
P80C31BH	4.54
P80C86AL-2	12.60
P8155H/2	6.98
P8185	18.10
P8205	2.00
P8212	2.40
P8226	2.40
P8251A	3.90
P8253	2.80
P8255A-5	3.90
P8259	2.85
P8259A	3.20
P8274	9.98
P8279-5	3.20
P8282	2.64
P8286	3.60
P82C54	4.10
P82C54-2	4.80
PAL10L8CN	1.90
PAL12H6CN	1.90
PAL16R4BCN	2.17
PAL20L10CNS	4.35
PAL20X8CNS	3.32
PALC16L8Q-25CQ	6.10
PALC20L8Z-45CQS	5.17
PALC22V10H-35QS	8.34
PCD8584P	8.28
PCF8566P	8.28
PCF8566T	8.28
PCF8570P	7.85
PCF8573P	6.72
PCF8574P	5.90
PCF8574T	5.90
PCF8591P	9.35
R6502AP	5.70
R6520P	4.40
R6522	4.40
R6522AP	5.80
R65C02P2	5.84
R65C02P3	6.90
R65C02P4	8.95
R65C102P2	6.85
R65C21P2	5.94
R65C22P2	4.80
SAB80C32P	5.95
SAB8155-P	3.82
SAB8259AP	3.59
SAB82C54-2-P	4.12
SAB82C55A-2-P	4.80
SC80C451ccn64	13.60
SCN2661bc1n28	3.35
SCN2661ccn28	3.35
PAL16R4-15CN	2.98
TL16C552FN	12.58
TMP7002NL-2	4.97
TMP8085AP-2	5.98
TMS3477NL	6.68
TMS3700NSB	8.78
TMS3702ANS	8.78
TMS3835ANS	7.55
TMS77C01NL	10.74
TMS9900NL	24.40
TMS9901NL	14.16
TMS9902ANL	15.94
TMS9914ANL	23.10
TMS9928ANL	7.40
TMS9995JDL	69.85
UA9636ACP	1.98
UA9637A	1.98
UA9638CP	1.98
UA9639CP	1.98
UM6845B	4.95
UM9151	POA
UM9151-3	POA
UPB8238	POA
UPB8282C	4.98
UPB8284AD	4.98
UPB8286C	4.98
UPD70108C-10	9.10
UPD70108C-8	6.95
UPD70116C-10	12.90
UPD70116C-8	9.20
UPD71055C	4.38
UPD7201AC	11.68
UPD7201C	6.80
UPD765AC	5.42
UPD765AC	5.42
UPD780C-1	4.76
UPD80C39HC	8.42
UPD8155HD	5.84
UPD8251AFC	4.08
UPD8253C-2	3.32
UPD8253C-5	3.32
UPD8286C	POA
UPD8741AD	12.52
UPD8749HC	13.98
V20-10MHz	9.10
V20-8MHz	6.95
V30-10MHz	12.90
V30-8MHz	9.20
V61C30P	7.80
VC0106N6	8.60
Z0800110PSC	16.90
Z0868112PSC	3.20
Z180-MPU	POA
Z8001B-CPU	11.96
Z8018008VSC	8.25
Z80A-CPU	1.25
Z80A-CTC	1.98
Z80A-DART	3.15
Z80A-DMA	3.95
Z80A-PIO	1.25
Z80A-SIO/0	3.40
Z80B-CPU	1.52
Z80B-CTC	3.00
Z80B-DART	5.80
Z80B-DMA	POA
Z80B-PIO	2.20
Z80B-SIO	4.50

TELECOM & SPECIAL FUNCTION ICs

62X0890-U18	3.70
707W02020	5.25
733W00124	5.25
AMA1503GXB	4.68
BAA1505	1.80
CLA25106/PLCC	5.95
GA05001GDB	3.20
KS-49258/PLCC	5.92
MJ1454BB	7.65
MK5175N	3.80
OC-147-7	2.40
PBD352303	4.35
PP34C108	6.80
Q4704	3.60
QMV16BP5	7.98
QMV18C	6.95
QMV18CN1	7.85
QMV18CW1	7.85
QMV25C	8.42
QMV62AW1	6.90
S4534-AMI	4.20
SA336931	2.95
SAA5025D	5.40
SCM66115P	3.40
SGS7P050	4.55
SP1450B	5.76
ULA1RB029E1	6.80
ULA20RK008E1	59.72
XR-T5683	3.60
ZNA2L029J-BS	3.80
ZNPCM1J-BS	8.95

OPTO ELECTRONICS

4N25	0.60
4N26	0.60
4N33	0.40
4N38	0.56
6N139	1.60
CNX36	0.38
CNY17-3	0.64
CNY21N	POA
DF08	0.40
HCPL-2200	5.98
HCPL-2231	5.98
HCPL-2602	5.68
HCPL-2630	3.68
HCPL-2730	3.45
HCPL-2731	3.20
HCPL-4200	5.98
ILD74	1.44
ILQ1	1.60
ILQ74	2.25
ISQ74	2.25
TIL100	1.98
TIL111	0.60
TIL113	0.60
TIL117	0.85
TIL119	1.20
TIL311	9.65
TLP504A	1.58
TLP521-4GB	4.20
TORX173	4.96
TOTX173	4.96

LINEAR & MISCS.

3630BM/BB	3.40
49620/BB	POA
555-TIMER	0.20
6341-1J	POA
741-OPAMP	0.18
AD0P07CN	2.14
AD520JN	POA
AD524	21.52
AD534JH	18.24
AD537JH	POA
AD548JN	1.53
AD578JN	POA
AD581JH	6.96
AD581KCSA/SMD	7.85
AD585AQ	24.60
AD592CN	14.68
AD594AD	10.56
AD595AD	6.65
AD648JN	3.40
AD707JN	2.82
AD711JN	2.34
AD712JN	3.34
AD7245JN	POA
AD741KN	3.69
AD7523KN	6.80
AD7537JN	27.11
AD7537LN	POA
AD7542KN	11.98
AD7543JCWE	POA
AD7578KN	40.15
AD844AN	8.75
ADC0804LCN	4.25
ADC0820CCN	22.40
ADC0834CCN	7.45
ADC804LCWM	12.10
ADC84KG-10	12.66
ADC908HP	16.42
ADDAC80N	19.74
ADG201AKN	4.86
ADOP07CN	1.60
AH0015CD	17.20
AY-3-1270	3.60
AY-5-1013	3.20
AY-5-1013A	5.24
AY-5-1250	POA
AY-5-3600-PRO	9.96
BA6109	1.68
BA6208	1.40
CA3046	0.51
CA3046(SMD)	0.89
CA3054	0.94
CA3059	1.20
CA3078AT	2.42
CA3079	0.88
CA3080E	0.70
CA3081	0.96
CA3089E	1.22
CA3094AE	2.16
CA3096AE	3.48
CA3096CE	2.67
CA3097E	2.60
CA3120E	POA
CA3130BT	19.20
CA3130E	1.10
CA3140AE	1.34
CA3140E	0.60
CA3146E	0.90
CA3160E	1.25
CA3240E	1.94
CA3240E1	2.16
CA324E	0.60
CA3260E	1.68
CA3280AE	5.94
CA3280E	3.42
CA555CE	0.20
CA741CE	0.18
CS5503-KD	POA
CX7925B	POA
D169CJ	POA
DAC0800LCN	4.10
DAC0832LCN	10.67
DAC08CP	2.60
DAC08EP	3.64
DAC1008LCN	10.73
DAC1222LCN	20.40
DG201ABK	3.83
DG211	1.56
DG508ACJ	5.95
DG508CJ	3.25
DS1488N	0.30
DS14C88M/SMD	1.65
DS14C88N	1.65
DS14C89AN	1.65
HA12017	1.44
HA13426	11.96
HA17723	1.10
HD75189P	POA
HEF4754V	22.20
HI1-0201-5	3.60
HI1-508A-5	11.21
HI1-549-5	POA
HI1-574AKD-5	42.50
HI3-0201-5	3.20
HI3-0509A-5	7.15
HI3-201-5	3.20
HIIL1	POA
HS574-AK	18.20
ICL7104-16CPL	26.08
ICL7107CQH/PLCC	5.20
ICL7109CPL	9.85
ICL7116CPL	5.25
ICL7117CPL	5.25
ICL7126CPL	5.35
ICL7135CPI	8.32
ICL7136CPL	6.55
ICL7137CPL	6.98
ICL7606CJN	12.24
ICL7611DCPA	1.32
ICL7621DCPA	1.98
ICL7622	POA
ICL7650CPD	4.48
ICL7650SCPD	5.64
ICL7652BCPD	8.24
ICL7652CPD	8.24
ICL7660CPA	1.40
ICL7660SCPA	3.80
ICL7662CPA	3.80
ICL7663BCJA	6.78
ICL7663BCPA	5.10
ICL7664CPA	7.95
ICL7665ACPA	4.98
ICL7673CPA	1.26
ICL8052ACPD	8.73
ICL8068AJD	9.65
ICL8069CCSQ	3.75
ICL8069DCSQ	2.68
ICL8069DCZR	2.85
ICL8211CPA	2.28
ICL8212CPA	1.10
ICM7170IPG	7.66
ICM7207AIPD	6.80
ICM7207IPD	6.80
ICM7209IPA	3.75
ICM7211AMIPL	4.02
ICM7211MIPL	4.02
ICM7212AMIPL	3.20
ICM7213IPD	4.58
ICM7216AIJI	18.05
ICM7217AIPI	7.20
ICM7217BIJI	10.42
ICM7217IJI	10.42
ICM7218AIJI	6.85
ICM7218AIPI	6.85
ICM7218DIJI	6.85
ICM7218EIJL	14.76
ICM7224IPL	7.77
ICM7226AIJL	26.12
ICM7226BIPL	25.04
ICM7249IDM	POA
ICM7555IBA	2.40
ICM7555IPA	0.64
ICM7556IPD	1.30
IM6403IPL	10.80
L272	2.10
L272M	2.10
L293E	3.90
L297A	4.69
L4805CV	2.20
L487	3.15
L4960	3.15
L702B	2.94
LA6250	POA
LA6358	POA
LA6510	POA
LA6520	POA
LC7132	2.30
LC7522	POA
LC7555	POA
LD111ACJ	POA
LF13508D	18.20
LF311H	10.80
LF347N	1.10
LF351N	0.60
LF353N	0.42
LF355N	0.70
LF356N	1.40
LF357BN	4.98
LF357M/SMD	4.98
LF357N	1.05
LF398N	2.75
LF411CN	0.75
LF412CN	1.21
LF441CN	0.75
LF442CN	0.99
LF444CN	2.40
LH0002CN	10.80
LH0032CG	33.60
LM101AH	5.65
LM10CN	9.24
LM111H	6.74
LM13600N	3.40
LM13700N	2.32
LM1391N	3.40
LM139J	6.60
LM1458N	0.45
LM1496N	2.95
LM1801N	7.92
LM1881N	3.60
LM1889N	7.40
LM1894N	4.16
LM218H	15.75
LM239N	3.90
LM2901N	1.16
LM2903N	0.85
LM2904N	0.85
LM2917N-14	6.10
LM2917N-8	5.80
LM294OCT15	2.73
LM294OCT5	2.10
LM2984CT	7.50
LM301AN	0.36
LM307N	0.84
LM308N	1.10
LM310N	2.98
LM311N	0.30
LM311N-14	2.15
LM312H	8.95
LM317AT	2.60
LM317T	0.52
LM317T-SGS	0.52
LM318N	2.60
LM319N	1.60
LM320LZ-12	0.34
LM324AN	3.66
LM324J	1.20
LM324N	0.35
LM325N	9.40
LM3301N	2.60
LM334Z	1.80
LM335Z	2.16
LM336Z-2.5	1.28
LM336Z-5.0	1.20
LM337T	1.15
LM339AN	1.10
LM339N	0.24
LM340AT12	1.68
LM340T-5	0.30
LM340T12	0.30
LM340T15	0.30
LM340T5	0.30
LM343H	8.80
LM346N	3.96
LM348DP	0.40
LM348N	0.40
LM350T	6.85
LM351N	2.60
LM358N	0.32
LM359N	4.68
LM360H	7.72
LM361M/SMD	6.40
LM363H-100	16.50
LM369DN	3.82
LM369DRC	3.70
LM380N	1.20
LM381AN	7.88
LM385Z-1.2	2.20
LM385Z-2.5	2.20
LM386M-1/SMD	1.65
LM386N-1	1.40
LM386N-3	1.80
LM386N-4	2.60
LM387AN	5.90
LM388N-1	4.25
LM389N	3.40
LM3900N	1.60
LM3909N	2.64
LM3914N	4.40
LM393N	0.30
LM393P	0.30
LM394CN	5.98
LM3999Z	2.76
LM399H	7.85
LM4250J	11.82
LM555CN	0.28
LM565CN	7.48
LM710CH	2.80
LM723CH	2.80
LM723CN	0.70
LM733CN	2.65
LM741CJ-14	2.20
LM741CN	0.45
LM747CH	2.40
LM747CN	0.90
LM78GCP	2.40
LM79GCP	2.40
LM833N	2.82
LS285AB	2.40
LS288B	3.60
LS7210	4.40
LT1006CNB	2.72
LT1010CT	4.58
LT1028CN8	7.32
LT1032CN	4.70
LT1070CT	9.14
LT1083CP	8.82
LT1086CT	2.90
LTC1052	7.97
LTC485CN8	2.16
LTC490	4.40
M5218AL	POA
M5220	POA
M5238L	POA
M5298P	POA
M706B1	1.25
MAX1232CNG	POA
MAX1232CPA	3.57
MAX1259CPE	POA
MAX162ACNG	POA
MAX232ACPE	4.84
MAX232CPE	2.80
MAX232EWE	3.80
MAX232N	2.80
MAX280CPA	6.94
MAX452CPA	5.38
MAX627CPA	2.98
MAX660CPA	5.72
MAX690ACPA	6.58
MAX694CPA	POA
MAX697CPE	POA
MAX7219CNG	7.15
MAX8211CPA	2.28
MAX901BCPE	POA
MC1377P	4.93
MC1413P	0.74
MC14411P	11.38
MC14416L	17.60
MC14495P	4.82
MC145406P	2.10
MC1455P	0.40
MC1455P1	0.60
MC1458P	0.32
MC1488L	2.40
MC1488P	0.58
MC1489A	0.80
MC1489AL	2.25
MC1489AN	0.80
MC1489L	2.20
MC1489P	0.46
MC1496N	2.20
MC1558L	3.32
MC1648P	12.40
MC1658P	12.78
MC1709CPI	1.20
MC1723CP	1.20
MC1741CP	0.45
MC3242AP	7.54
MC3301P	0.88
MC3302P	0.60
MC3340P	1.60
MC3357P	3.20
MC3403P	1.40
MC3446AP	6.75
MC3479P	7.92
MC3523U	5.80
MC4024P	12.78
MCT2	0.84
MCT61	1.18
MF10CCN	8.95
ML924	4.90
MM5309N	5.76
MM53105N	4.98
MM80C95N	1.44
MP7570JD	POA
MUX24EQ	9.60
MUX24FP	9.60
MV500DP	3.05
MV601DP	3.36
MV8870DP	5.52
NE5020N	10.84
NE527N	3.71
NE532N	0.60
NE536H	4.90
NE5530N	3.82
NE5532AN	1.58
NE5532N	0.80
NE5534AN	1.80
NE555N	0.20
NE556/SMD	0.70
NE556N	0.38
NE558N	2.28
NE564N	3.42
NE565N	2.94
NE567N	0.65
NE568N	3.85
NE570N	4.60
NE571N	3.40
NE589N	4.25
NE592/SMD	1.80
NE592N	1.40
NE592N14	0.92
NE602AN	2.98
NE602N	2.25
NE604AN	7.20
NE612AN	2.87
NJM4556D	1.20
NJM4556S	1.20
NJM4558DX	1.20
NJM4558S	1.20
OP07CJ	3.60
OP07CN	0.95
OP07CP	0.95
OP07EP	3.10
OP11GP	5.85
OP177FP	3.71
OP27GP	2.89
OP42FZ	7.44
OP77GP	2.07
OPO7CN	0.95
PM7548HP	14.04
RC4136N	0.90
RC4193N	POA
RC4194N	2.85
RC4207GN	1.92
RC4558	0.90
RC4558P	0.60
REF01CP	2.10
REF01HP	2.98
REF02CP	2.30
REF03GP	2.30
REF25Z	1.12
S2560A	POA
SAA1027	6.51
SAA1043P	7.98
SAA3049P	9.92
SAA5025D	7.65
SAA6002A	10.80
SAS560S	3.40
SED2000FVA	9.60
SFC2301ADC	6.78
SFC2741DC	0.18
SG3524N	4.60
SI7660CJ	1.92
SL1452	6.75
SL2364C	3.97
SL3117B	POA
SL486DP	2.98
SL490B	2.51
SL560CDP	3.00
SL627OC	3.30
SL6700CDP	5.47
SN5281CN	POA
SN55451BJG	POA
SOC12	0.20
SP1648DG	5.53
SP4534	POA
SP4740DP	4.46
SP8629DP	3.44
SP8660DP	4.96
TA7215P	7.20
TA7256P	2.60
TA7368P	POA
TA7658P	POA
TA78005AP	POA
TA8200AH	POA
TA8410K	2.80
TA8449P	POA
TA8659AN	POA
TAA861A	POA
TBA120S	0.60
TBA240B	POA
TBA570	POA
TBA820MT	POA
TBA920	POA
TBA990	POA
TC9106BP	POA
TCA335A	POA
TCA965	POA
TCM1520AP	1.98
TCM1531P	POA
TCM1705AN	POA
TCM3105N	8.97
TCM5087N	2.40
TCM5089N	2.40
TDA1083	2.60
TDA1085A	2.96
TDA1085C	3.80
TDA1151	1.10
TDA1170S	2.80
TDA1515A	4.98
TDA1521A	4.37
TDA1576	2.95
TDA1578A	3.60
TDA2595	3.32
TDA3048N	1.85
TDA3505	POA
TDA3810	POA
TDA440	POA
TDA4510	3.38
TDA4563	3.38
TDA4660	POA
TDA7010T	POA
TDA7052	2.52
TDA8702	6.22
TEA1045	POA
TEA1060	4.20
TEA5620	POA
TIPC2801KV	8.40
TL026CP	1.84
TL062CN	0.48
TL062CP	0.48
TL064CD	0.98
TL064CN	0.48
TL064ID/SMD	2.10
TL071ACP	1.84
TL071CP	0.48
TL072ACP	1.84
TL072CN	0.50
TL072CP	0.50
TL074ACN	2.85
TL074CN	0.84
TL081CP	0.34
TL082CP	0.36
TL084CN	0.48
TL27L2CD/SMD	1.40
TL497ACN	3.14
TL507CP	4.03
TL7702ACP	2.04
TL7705ACP	2.04
TL7705CP	2.04
TL7709ACP	2.04
TL7770-SC	3.82
TL783CKC	3.06
TLC2201CP	3.06
TLC2202CP	3.06
TLC2274CN	2.85
TLC251CP	2.54
TLC2652CP	4.46
TLC2654CP	4.29
TLC271CP	0.84
TLC272CP	1.30
TLC274CN	2.40
TLC339CN	1.45
TLC372CP	1.40
TLC551CP	3.68
TLC555CP	0.65
TLC556CN	1.14
TLC7524CN	6.86
TLE2061CP	2.20
TLE2062CP	3.40
TLE2064CN	3.45
TLE2161CP	2.42
TMS3477NL	5.96
TPIC2406NE	7.14
TPIC2802KV	8.40
TPIC6259N	3.28
TPIC6273N	3.28
TPIC6595N	3.28
TSC426CPA	POA
TSC500CPE	POA
TSC7106CPL	6.81
TSC7116CPL	5.25
TSC7126CPL	5.35
TSC766OCPA	1.40
U1096B	4.92
U2066B	2.64
U2400B	5.50
U664B	3.95
UA2240PC	1.40
UA709CP	0.85
UA709PC	0.85
UA715HC	4.50
UA723CP	0.70
UA733CJ	2.98
UA741MP	0.60
UA741TC	0.28
UA748CP	0.36
UA748TC	0.52
UA77000UIC	POA
UA798TC	3.80
UCN5800A	2.40
UCN5801A	2.60
UDN2981A	2.00
UDN2982A	2.00
UDN6118A	1.65
UGN3501M	POA
ULN2001AN	0.44
ULN2002A	0.44
ULN2003AN	0.44
ULN2004AN	1.40
ULN2024A	1.40
ULN2032A	1.40
ULN2803AN	0.84
UM5100	POA
UM5101	3.80
XR2211CP	POA
XTR110KP	9.95
Y1112/TI	4.60
ZN1445	POA
ZN414Z	1.04
ZN415E	1.84
ZN423	2.20
ZN425E-8	4.46
ZN426E-8	3.68
ZN428E-8	5.98
ZN429E-8	2.32
ZN449E	4.76

75 SERIES

75107	1.02
75107A	1.02
75108	1.80
75108A	1.84
75108B	2.08
75109A	2.46
75110A	1.36
75113	3.02
75114	3.04
75115	1.60
75116	3.30
75121	2.60
75122	POA
75136	3.10
75138	4.40
75140	2.65
75150	1.60
75150M	2.65
75152	6.36
75154	1.75
75154M	1.75
75155	1.20
75157	4.40
75159	5.45
75160A	5.95
75161A	6.47
75162A	7.59
75172NG	3.68
75173	3.68
75174	3.20
75174NG	3.68
75175	2.60
75176A	1.60
75176B	2.28
75176BT	4.98
75177	2.60
75178	2.60
75182	2.60
75183	2.60
75188	0.40
75189	0.85
75189A	0.85
75361	2.84
75365	2.72
75437A	3.26
75450B	0.64
75451	0.28
75451B	0.48
75452	0.28
75452B	0.48
75453	0.64
75453B	0.64
75454	0.64
75454B	0.98
75462	0.98
75463	1.10
75468	3.60
75469	1.30
75470	POA
75471	1.68
75472	1.48
75473	1.48
75474	2.25
75477	2.10
75491	0.68
75ALS176	2.88
75ALS192	2.88
75ALS193J	3.22
75C1154	2.88
75C1406	2.73
75C185	3.98
75C188	1.20
75C189A	1.32
75C189AD	1.32
75LBC176	2.60

TRANSISTORS THYRISTORS & TRIACS

2N2219A	0.28
2N2222	0.28
2N2222A	0.20
2N2369	0.24
2N2369A	0.20
2N2484	0.32
2N2894	0.78
2N2905	0.29
2N2905A	0.32
2N2907	0.27
2N2907A	0.30
2N2923	0.30
2N2243	0.78
2N3053	0.32
2N3055	0.76
2N3441	1.20
2N3553	0.98
2N3684	1.68
2N3702	0.10
2N3704	0.10
2N3706	0.10
2N3725	0.78
2N3789	2.16
2N3819	0.38
2N3866	1.20
2N3904	0.10
2N3905	0.10
2N3906	0.10
2N3958	2.12
2N4037	0.48
2N405	2.30
2N4062	0.32
2N4091	0.78
2N4123	0.10
2N4124	0.20
2N4125	0.18
2N4126	0.32
2N4221A	2.96
2N4236	3.72
2N4401	0.18
2N4403	0.18
2N4921	1.40
2N5401	0.13
2N5415	0.72
2N5449	0.88
2N5459	0.52
2N5485	0.48
2N5876	1.32
2N6034	0.72
2N6037	0.72
2N6050	3.12
2N6051	3.49
2N6054	2.20
2N6056	1.94
2N6057	2.24
2N6058	2.68
2N6109	0.78
2N6125	2.88
2N6388	0.98
2N6517	0.34
2N6519	0.34
2N6668	1.40
2N696	0.26
2N706A	0.48
2SA1015	0.10
2SA1048/O	0.14
2SA1048Y	0.14
2SA1096R	0.74
2SA1100	0.52
2SA1102	2.10
2SA1104	2.10
2SA1111	1.18
2SA1115	0.80
2SA1145	0.80
2SA1263N	1.70
2SA1264N	2.80
2SA1265N	2.76
2SA1283	0.24
2SA1295	2.76
2SA1302	3.74
2SA1399	0.78
2SA1482	0.78
2SA1515	0.78
2SA1516	3.72
2SA156	1.40
2SA235	1.60
2SA485	1.80
2SA545	0.78

IC SOCKETS LOW PROFILE

No. of Pins	Pin spacing	Gold Turn Pin	Tin sldr Tail	Gold sldr Tail
6	0.3	18p	6p	18p
8	0.3	18p	6p	18p
14	0.3	31p	8p	31p
16	0.3	33p	10p	33p
18	0.3	39p	11p	39p
20	0.3	45p	12p	45p
22	0.3	54p	14p	
24	0.3	54p	14p	
24	0.6	54p	14p	
28	0.6	60p	16p	
32	0.6	65p	22p	
40	0.6	70p	22p	
48	0.6	85p		
64	0.75	260p		
64	0.9	260p		

PERSONAL COMPUTER - HARDWARE& SOFTWARE

MOTHER BOARDS

Processor Intel	Bus	Chip Set	BIOS	Cache RAM	Expend Memory	Expension Slots	BoardSize in mm	Pirce £ p
80486DX2-66	ISA	SIS	AMI	256K	32MB	6x16bit,1x8bit	245 x 220	499.00
80486DX2-66	ISA	ALI	AMI	256K	32MB	5x16bit,2x8bit	220 x 220	490.00
80486DX-50	ISA	SIS	AMI	256K	32MB	6x16bit,1x8bit	245 x 220	450.00
80486DX-50	ISA	ALI	AMI	256K	32MB	5x16bit,2x8bit	220 x 220	444.00
80486DX-33	ISA	SIS	AMI	256K	32MB	6x16bit,1x8bit	245 x 220	349.00
80486DX-33	ISA	ALI	AMI	256K	32MB	5x16bit,2x8bit	220 x 220	325.00
80486SX-25	ISA	SIS	AMI	128K	32MB	6x16bit,1x8bit	245 x 220	220.00
80386DX-40	ISA	SIS	AMI	64K	16MB	6x16bit,1x8bit	220 x 220	128.00
80386SX-33	ISA	SIS	AMI	0K	16MB	6x16bit,1x8bit	220 x 220	79.00
80486DX2-66	VESA	SIS	AMI	256K	32MB	7x16(AT),2x32(VESA)	260 x 220	510.00
80486DX-50	VESA	SIS	AMI	256K	32MB	7x16(AT),2x32(VESA)	260 x 220	470.00
80486DX-33	VESA	SIS	AMI	256K	32MB	7x16(AT),2x32(VESA)	260 x 220	349.00

All Mother Boards are supplied with Zero K bytes of RAM. Add £28 per MegaByte of RAM.

CONNER HARD DISK DRIVES

CP-30104E	120MB	19msec 3.5" LP	£189.00
CP-30174E	170MB	19msec 3.5" LP	£219.00
CP-30344	343MB	13msec 3.5" LP	£575.00

QUANTUM HARD DISK DRIVE

ELS-170	170MB	17msec 3.5"LP	£170.00

FLOPPY DISK DRIVES

TEAC	FD-235HF	1.44MB 3.5"	£35.00
TEAC	FD-55GFR	1.2MB 5.25"	£39.00
TEAC	FD-505	3.5"+ 5.25"	£99.00
MITSUMI	D359T3	1.44MB 3.5"	£35.00
MITSUMI	D509V3	1.2MB 5.25"	£32.00
MITSUBISHI	MF355C/258MG	1.44MB 3.5"	£29.00
MITSUBISHI	MF504C/318MP	1.2MB 5.25"	£35.00
CANON	MD5501-V6	3.5"+5.25"	£99.00

FLOPPY DISKS

MANUF.	3.5"/1.44MB	5.25"/1.2MB
TDK	£ 10.65	£ 7.45
SONY	£ 10.10	£ 7.65
FUJI	£ 10.10	£ 7.65
MITSUBISHI	£ 10.70	£ 7.00
UNBRANDED	£ 6.50	£ 4.50

Price per Box of 10 Disks

GRAPHIC CARDS

TRIDENT	TVGA 8900	Trident 1MB SVGA	£41.00
TRIDENT	TVGA 8900CL	New Trident 1MB SVGA	£44.00
CIRRUS LOGIC	XXXX	1MB SVGA	£52.00
TSENG LAB	ET-4000	1MB SVGA	£60.00
METHEUS	Premier 1280 NI	New Premier S3	£299.00
METHEUS	Premier 1M	TSENG LABS ET4000	£240.00

KEYBOARD & MICE

MITSUMI	KPQ-E99YC	102 UK KeyBoard, Regular Size	£20.00
MITSUMI	KPQ-E99AC	102 UK KeyBoard, Space Saver	£20.00
BTC	7849R	102 UK KeyBoard, Regular Size	£24.00
MSI SYSTEM MOUSE 3 Button Serial			£10.00

I/O CARDS

I/O	2S/1P/1G with cables	£10.00
IDE	2HD/2FD with cables	£10.00
IDE	2HD/2FD/2S/1P/1G/512kB with cables	£15.00
IDE99/512k	CACHE Controller, 2MB RAM, Max 8.5MB	£89.00
IDE99/2.5MB	CACHE Controller, 2.5MB RAM, Max 8.5MB	£125.00

MICROPROCESSORS

80286-16MHz	INTEL	£65.00
80386DX-40MHz	AMD	£75.00
80486SX-25MHz	INTEL	£125.00
80486DX-33MHz	INTEL	£275.00
80486DX-50MHz	INTEL	£375.00
80486DX2-66MHz	INTEL	£350.00

CO-PROCESSORS

80287-8	INTEL	£40.00
80287-10	INTEL	£48.00
80287-XL	INTEL	£65.00
80387DX-33MHz	INTEL	£65.00

MEMORIES

SIMM 1Mx9x9 CHIP 70ns	£28.00
SIMM 1Mx9x3 CHIP 70ns	£29.00
SIMM 4Mx9x9 CHIP 70ns	£107.00
SIMM 4Mx9x3 CHIP 70ns	£107.00
SIMM 256Kx9 CHIP 8Ons	£10.00

SOFTWARE

MICROSOFT ORIGINAL

MS DOS 5	£40.00
MS DOS 5/WINDOWS 3.1	£82.00
MS DOS 6	P.O.A.

IMPORTANT
All prices quoted are Excluding V.A.T.

Postage & Packing Charge of £3.00 is applicable to all goods under the heading of 'Personal Computer Hardware & Software'.

Postage & Packing will be charged at cost for all destinations outside the United Kingdom.

PLEASE SEE PREVIOUS ISSUES FOR OTHER ITEMS & FEB/MAR 1992 ISSUES FOR LEDs,DISPLAYS & RELAYS.

VIEWCOM ELECTRONICS

77 UPPERTON ROAD WEST
PLAISTOW, LONDON E13 9LT

PLEASE PHONE/WRITE FOR ITEMS NOT LISTED

PLEASE ADD 95p P & P and then 17.5% VAT. OFFICIAL ORDERS from Govt. & Educational Establishments are accepted. VAT at 17.5% is chrageable to all orders received from EC Member Countries unless VAT Number is quoted. OVERSEAS orders, postage AIR/SURFACE will be charged at cost. VAT is not applicable for EXPORT orders from Non-EC Member Countries. Stock items by return of post.
N.B. All prices are subject to change without notice & stock availability.

Retail Shop: 139, New City Road, Plaistow, London E13 9PX

535 CARD WITH EPROM EMULATOR (PART 2)

Although there is also a signal on the $\overline{\text{ACK}}$ line of the Centronics interface in emulator mode (unless JP6 is swapped), this of little consequence because the BUSY line is held high permanently in run mode. If you use P4.0 as an input, make sure that the line does not short-circuit the output of your application when 'emulator' mode is used. It is, therefore, recommended to drive P4.0 from an open-collector or open-drain output. This avoids the risk of short-circuits, while a pull-up resistor is not required because it is already contained in the controller.

If you want to use the Centronics input in an application, do remember that the circuit is switched to emulator

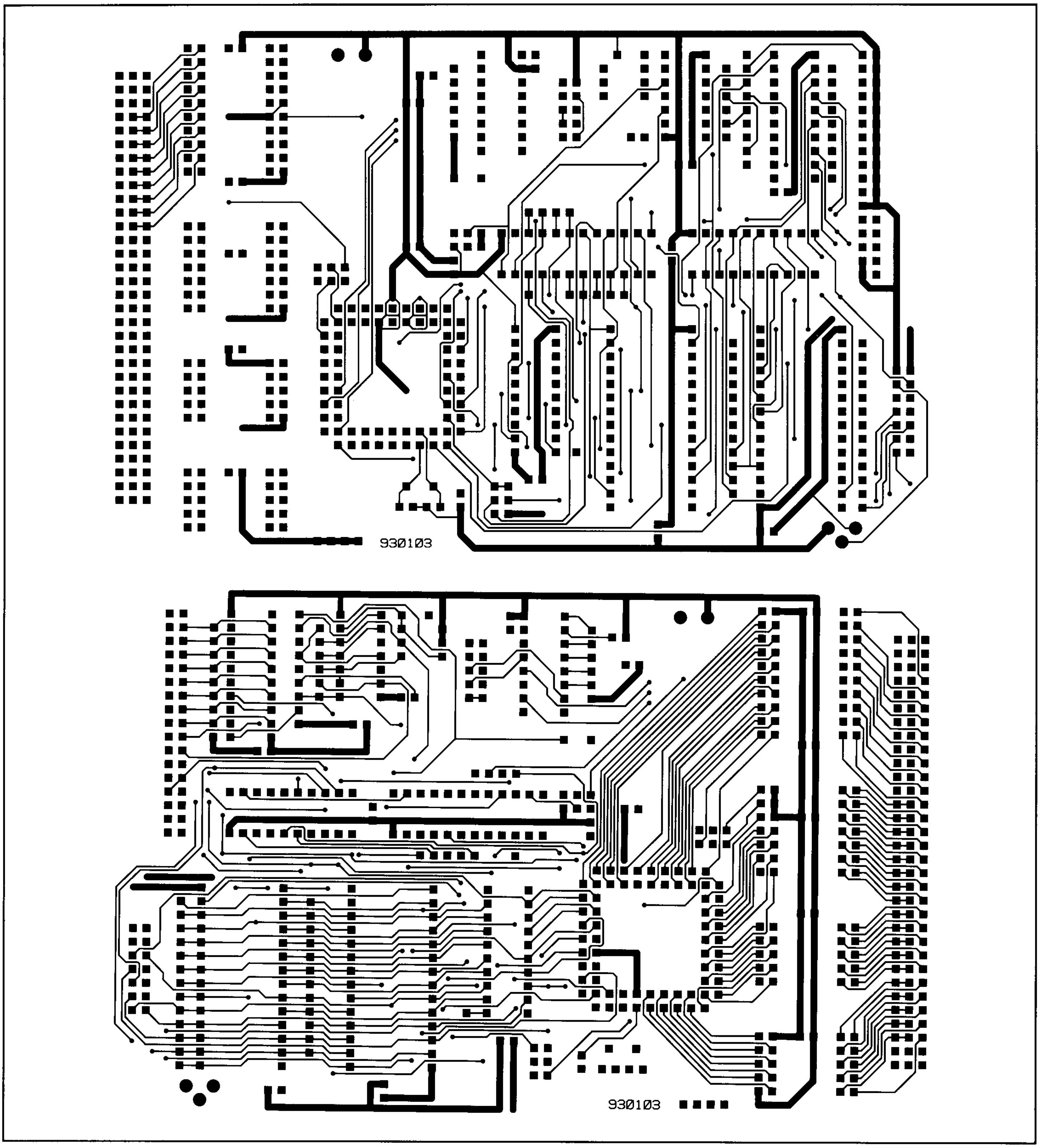


Fig. 3a. Track layouts of the double-sided through-plated printed circuit board designed for the 535 system.

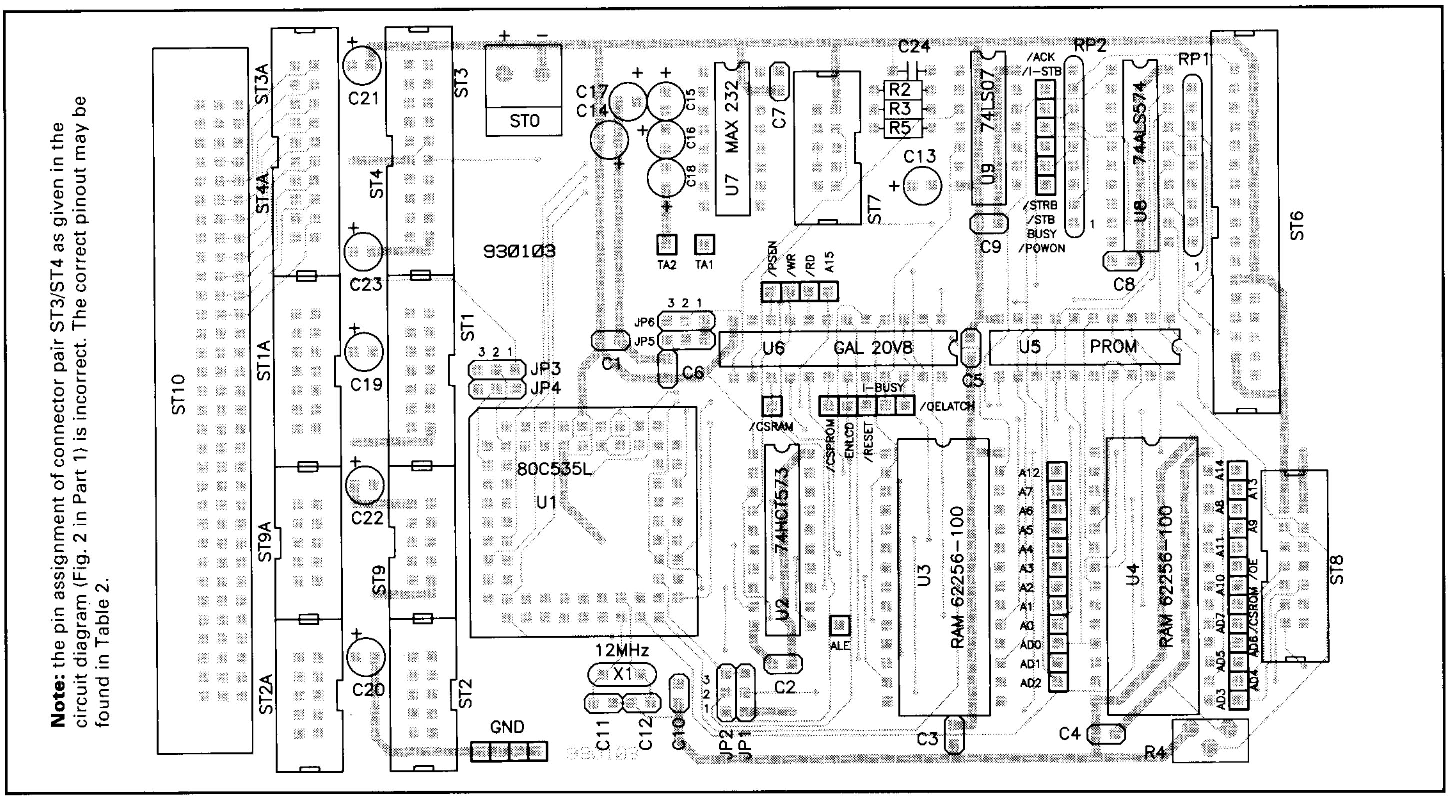
mode when a strobe pulse is received. Since it not normally possible to copy data into the data latch without making use of the strobe pulse, the jumper shown in the block diagram must be swapped to enable a program to be tested. Once that is done, the GAL can no longer switch the circuit to emulator mode. The same jumper is also swapped if EPROM instead of RAM is used for the program memory.

The 535 system

The circuit diagram of the 535 system, **Fig. 2**, is basically a worked out copy of the block diagram, with only a few extra details that require explanations. Among these details are the test points marked with 'P's and the signal name.

The 535 board may be built in two versions: with emulator or without emulator. The version with emulator is typically used to test software for applications of the 535 board. Once the test and debugging phases have been completed successfully, the software may be burned into EPROM for use on a 535 system without an emulator function. The difference between the two versions is, of course, the presence of the parts required for the emulator function. In a system without emulator function, components U5, U8, U9, RP1, ST6, R2, R5 and C24 may be omitted, while pins 8 and 9 of the socket for U9 are interconnected. Note, however, that the GAL (U5) and the PROM (U6) for this project are always supplied as a set, i.e., these parts can not be ordered separately.

As a consequence of the user being able to configure the system with or with an emulator function, provision must be made to use RAM or (EP)ROM respectively for the program memory. Because there are two differences in the pin order of 32-kByte RAMs and



Note: the pin assignment of connector pair ST3/ST4 as given in the circuit diagram (Fig. 2 in Part 1) is incorrect. The correct pinout may be found in Table 2.

Fig. 3b. Component mounting plan.

COMPONENTS LIST

Resistors:

1	2kΩ2	R2
1	10kΩ	R3
1	10kΩ preset H	R4
1	10Ω	R5
2	8-way 10kΩ SIL array	RP1;RP2

Capacitors:

10	100nF	C1-C10
2	27pF	C11;C12
1	10µF 6V3 tantalum	C13
3	10µF 6V3	C14;C15;C17
2	10µF 16V	C16;C18
5	1µF 6V3	C19-C23
1	4nF7	C24

Semiconductors:

1	SAB80C535L	U1
1	74HCT573	U2
2	RAM 62256-100	U3;U4
1	PROM TBP28L22*	U5
1	GAL 20V8-15*	U6
1	MAX232	U7
1	74LS574	U8
1	74LS07	U9

IC-sockets:

1	68-pin PLCC	
2	28-pin	
1	24-pin, 0.3" wide	
3	20-pin	
1	16-pin	
1	14-pin	

Miscellaneous:

6	3-way pin header with jumper	JP1-JP6
1	12MHz quartz crystal	X1
1	2-way PCB terminal block, pitch 5mm	ST0
5	10-way boxheader	ST2;ST2A;ST7;ST9;ST9A
3	14-way boxheader	ST1;ST1A;ST8
4	20-way boxheader	ST3;ST3A;ST4;ST4A
1	96-way DIN41612 connector (a-b or a-c row)	ST10
1	Press-key, make contact (reset)	
1	Printed circuit board 930103*	

* PROM U5, GAL U6 and the PCB for this project are available as a set under order code 930103. The PROM and GAL are also available separately under order code 6311. Price and ordering information on page 110.

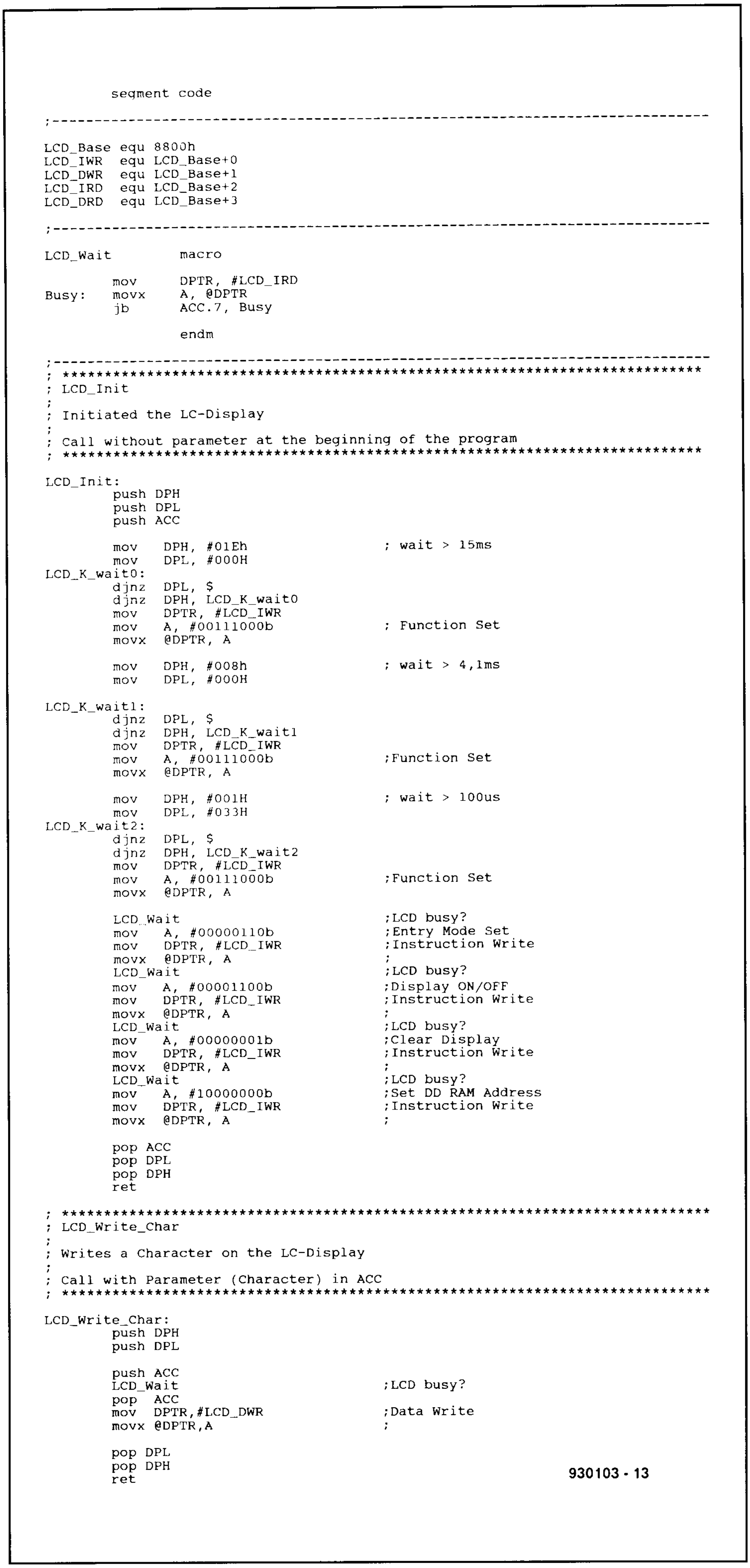
Options:

LCD-module, e.g., LM093LN (Hitachi) or compatible type.

MCS51 assembler course software:

1661 MSDOS version

1681 Atari version



```
        seqment code

;--------------------------------------------------------------------------

LCD_Base equ 8800h
LCD_IWR  equ LCD_Base+0
LCD_DWR  equ LCD_Base+1
LCD_IRD  equ LCD_Base+2
LCD_DRD  equ LCD_Base+3

;--------------------------------------------------------------------------

LCD_Wait        macro

        mov     DPTR, #LCD_IRD
Busy:   movx    A, @DPTR
        jb      ACC.7, Busy

                endm

;--------------------------------------------------------------------------
; *************************************************************************
; LCD_Init
;
; Initiated the LC-Display
;
; Call without parameter at the beginning of the program
; *************************************************************************

LCD_Init:
        push DPH
        push DPL
        push ACC

        mov   DPH, #01Eh                ; wait > 15ms
        mov   DPL, #000H
LCD_K_wait0:
        djnz  DPL, $
        djnz  DPH, LCD_K_wait0
        mov   DPTR, #LCD_IWR
        mov   A, #00111000b             ; Function Set
        movx  @DPTR, A

        mov   DPH, #008h                ; wait > 4,1ms
        mov   DPL, #000H

LCD_K_wait1:
        djnz  DPL, $
        djnz  DPH, LCD_K_wait1
        mov   DPTR, #LCD_IWR
        mov   A, #00111000b             ;Function Set
        movx  @DPTR, A

        mov   DPH, #001H                ; wait > 100us
        mov   DPL, #033H
LCD_K_wait2:
        djnz  DPL, $
        djnz  DPH, LCD_K_wait2
        mov   DPTR, #LCD_IWR
        mov   A, #00111000b             ;Function Set
        movx  @DPTR, A

        LCD_Wait                        ;LCD busy?
        mov   A, #00000110b             ;Entry Mode Set
        mov   DPTR, #LCD_IWR            ;Instruction Write
        movx  @DPTR, A                  ;
        LCD_Wait                        ;LCD busy?
        mov   A, #00001100b             ;Display ON/OFF
        mov   DPTR, #LCD_IWR            ;Instruction Write
        movx  @DPTR, A                  ;
        LCD_Wait                        ;LCD busy?
        mov   A, #00000001b             ;Clear Display
        mov   DPTR, #LCD_IWR            ;Instruction Write
        movx  @DPTR, A                  ;
        LCD_Wait                        ;LCD busy?
        mov   A, #10000000b             ;Set DD RAM Address
        mov   DPTR, #LCD_IWR            ;Instruction Write
        movx  @DPTR, A                  ;

        pop ACC
        pop DPL
        pop DPH
        ret

; *************************************************************************
; LCD_Write_Char
;
; Writes a Character on the LC-Display
;
; Call with Parameter (Character) in ACC
; *************************************************************************

LCD_Write_Char:
        push DPH
        push DPL

        push ACC
        LCD_Wait                        ;LCD busy?
        pop  ACC
        mov  DPTR,#LCD_DWR              ;Data Write
        movx @DPTR,A                    ;

        pop DPL
        pop DPH
        ret
```

930103 - 13

Fig. 4. Example of an LCD driver for the 535 controller.

EPROMs, jumpers JP1 and JP2 are added. These jumpers may be set to RAM or EPROM, just like JP5 and JP6.

The use of the Centronics interface for the emulator function leaves the controller's serial interface free for your own applications. Note, however, that the controller is capable of receiving and generating TTL level signals only. A MAX232 single-chip TTL/RS232 level converter is, therefore, used to allow the controller to be connected to a standard RS232 port on a PC.

Apart from digital I/O ports, the SAB80C535 also has eight analogue inputs, which are connected to an on-board 12-bit A-D (analogue-to-digital) converter. Jumpers JP3 and JP4 enable you to select either the supply voltage or an external voltage (max. 5 V; via ST1) as the ADC reference.

Finally, preset R4 acts as a contrast control for the LC display, which is connected to ST8.

Construction

The complete circuit is easily accommodated on a single Eurocard-size (100×160 mm) printed circuit board, which is double-sided and through plated. This board is available ready-made through our Readers Services, together with the programmed GAL and PAL. The artwork for the 535 board is given in Fig. 3. Connectors ST1-ST4 are 'twins', while ST10 is fitted alongside the edge of the board to enable this to be fitted in a 19-inch case, or to be connected to another board. Connectors ST1A to ST4A enable the connection of ST1-ST4 and ST9 to ST10 to be 'tailored' to requirements. This is useful when the card is to be connected to an existing system. If you are not bound by an existing system, simply make the connection go straight across the board using two press-on (IDC) sockets and a length of flatcable. The relevant pin connections are given in **Table 2**.

If it is desired to fit the board into a 19-inch enclosure, special attention should be given to connectors ST0, ST2(A), ST3(A), ST8, and resistor R4. These parts are located close to the board edge, and make it impossible to use the card guides normally present in 19-inch racks. You may just be lucky with ST8 and R4, but lacking space for the boxes, ST2(A) and ST3(A) will have to be changed into normal pin headers. Also, PCB terminal block ST0 may have to be turned 180° to enable the supply wires to be inserted from the centre of the board.

The connection order of 34-way boxheader ST8 is identical to that of the Centronics connector, with the exception of two missing pins (36-way box headers do not exist). This does not cause problems if you use a length of flatcable between ST8 and the Centronics connector, making sure that pin 1 on one connector goes to pin 1 of the other (use the single coloured wire on one side of the flatcable for this purpose). Pins 18 and 36 of the Centronics connector are not used. Also, remember that there is no pin-for-pin correspondence between the Centronics connector at the side of the 535 system and the 25-way sub-D connector at the side of the PC. Therefore keep in mind that some wires will have to be crossed if you use a flatcable to establish the connection between ST8 and the PC's printer port. The best way to avoid all problems in this regard is to use a ready-made IBM PC parallel printer cable, which is often cheaper than two connectors and a length of flatcable.

Software

Like many other microcontroller boards, the present 535 system board is not more than the basis of a larger circuit designed to perform a certain function in conjunction with dedicated software. An example of a circuit based on a 80C535 microcontroller core is the Watt-hour meter (Ref. 2).

As already mentioned, you will need an assembler to be able to produce software for the 535 board. Fortunately, MCS51 assemblers come in a wide variety of levels and capabilities. If you are on a tight budget, do consider the assembler contained on the '8051/80C32 assembler course' diskette (Ref. 3), which is good value for money. Note, however, that the examples on this course disk may require small modifications because of the different memory structure of the 535 board.

A programming example specifically written for the present 535 board is given in **Fig. 4**. This is the listing of an LCD driver, which may be used to write messages on to the LCD that tell you what has happened during the course of a program under development. Alternately, such messages many be written to the PC via the RS232 interface on the 535 board. The routine shown in **Fig. 4** has been written with a so-called macro assembler, which enables frequently called, small, program chunks to be defined only once. An example of such a macro is found at the top of the listing. Unfortunately, the assembler mentioned above does not support the use of macros. Consequently, the three individual instructions that make up the macro (LCD_Wait) must be repeated at every location this macro appears in the program. ■

References:

1. I^{2}C alphanumerical display. Elektor Electronics September 1993.
2. Watt-hour meter. *Elektor Electronics* February 1993.
3. 8051/8032 assembler course. *Elektor Electronics* February through November 1992. Disk/EPROM order code: 1661 (see page 70).

USER INSTRUCTIONS

Load emulator RAM:

1. Connect the printer port on your PC to the Centronics input on the 535 board.
2. Switch on the 535 board, which then waits for the first program to be downloaded.
3. On the PC, type
   COPY <file> PRN: /b
   to print the program to the 535 board in the form of a binary file. The /b switch prevents the COPY command from interpreting the value $1A_H$ as an end-of-file code.
4. The emulator program on the 535 board automatically loads the received data into the program memory, starting at 0000_H.
5. One second after the last received byte, the processor is reset, and the downloaded program is started from 0000_H.
6. The running program is interrupted by a reset when the PC sends new data. Next, the emulator program (downloader) contained in PROM is started again. Steps 3, 4 and 5 follow.
7. The effect of pressing the reset button depends on the program executed by the controller. With the emulator program (downloader) running, the Centronics BUSY signal is reset, and the load routine is initialized. Loading will continue from address 0000_H. With the controller running the program contained in the program memory, pressing the reset key causes a normal system reset. The processor is reset, and the execution of the program starts at 0000_H.

Hardware options:

535 board with emulator

1. IC position U4 has a RAM type 62256.
2. Jumper settings: JP2: 1-2; JP1, JP5 and JP6: 2-3.

535 board with EPROM

1. IC position U4 has an EPROM type 27256.
2. Jumper settings: JP2: 2-3; JP1, JP5 and JP6: 1-2
3. Only if the board is used with a program in EPROM: omit U5, U8, U9, RP2 and ST6. Interconnect pins 8 and 9 of IC socket U9.

Analogue reference voltage

Internally (5 V): JP3, JP4: 1-2.
Externally (max. 5 V): JP3, JP4: 2-3.

signal	pin		signal		pin			
					row a	ST10		row b/c
					1			1
					2			2
	ST2					ST2A		
P1.0	2	1	+5V		3	2	1	3
P1.2	4	3	P1.1		4	4	3	4
P1.4	6	5	P1.3		5	6	5	5
P1.6	8	7	P1.5		6	8	7	6
GND	10	9	P1.7		7	10	9	7
	ST9					ST9A		
P3.7	9	10	GND		8	9	10	8
P3.5	7	8	P3.6		9	7	8	9
P3.3	5	6	P3.4		10	5	6	10
P3.1	3	4	P3.2		11	3	4	11
+5V	1	2	P3.0		12	1	2	12
	ST1					ST1A		
AN0	2	1	+5V		13	2	1	13
AN2	4	3	AN1		14	4	3	14
AN4	6	5	AN3		15	6	5	15
AN6	8	7	AN5		16	8	7	16
GND	10	9	AN7		17	10	9	17
GND	12	11	VAGND		18	12	11	18
GND	14	13	VAREF		19	14	13	19
	ST3/ST4					ST3A/ST4A		
P4.7	19	20	GND		20	19	20	20
P4.5	17	18	P4.6		21	17	18	21
P4.3	15	16	P4.4		22	15	16	22
P4.1	13	14	P4.2		23	13	14	23
+5V	11	12	P4.0		24	11	12	24
P5.0	9	10	+5V		25	9	10	25
P5.2	7	8	P5.1		26	7	8	26
P5.4	5	6	P5.3		27	5	6	27
P5.6	3	4	P5.5		28	3	4	28
GND	1	2	P5.7		29	1	2	29
					30			30
					31			31
					32			32

Table 2. Connector pinning overview to help you find signals on the board.

VIEWS OF THE BRIDGE

Part 1: Power rectification

By Bryan Hart

The diode-quad bridge network is a familiar component in power-supply design. However, the discussion of its operation in the technical literature generally, and in electronics textbooks in particular, is often superficial and a reader can easily get the feeling that 'something is missing' from the explanations. This feeling is intensified in attempting to explain oscilloscope traces of observed circuit waveforms. This article takes a fresh look at the bridge. Part 1 supplies a fuller account of its operation in power rectification than is normally given and Part 2 discusses the wider applicability of this versatile component assembly in the field of instrumentation.

Bridge construction

Figure 1(a) shows two series-connected diodes, D_1 and D_2, arranged in parallel with a similarly connected pair, D_3 and D_4. Note that at this stage all the diodes 'point the same way'. If we now imagine the junction points **A** and **B** to be pulled out in the directions indicated by the arrows, then we arrive at the 'square' (or 'diamond') shape shown in **Fig. 1(b)**. In this more usual form, which we will use from now on, this diode-quad connection is frequently referred to as a 'bridge' by analogy with the well-known Wheatstone bridge component arrangement. An alternative drawing, used in older texts, is shown for completeness in **Fig. 1(c)**. This figure-of-eight representation is not so popular nowadays. Certainly, the diode polarity is not so easily remembered as it is for **Fig. 1b**.

The diode bridge can be purchased as an encapsulated module for power-rectification applications or be constructed from signal diodes, such as the popular general-purpose Type 1N4148, for miscellaneous low-power applications. The intended application determines which of the points **A**, **B**, **X**, **Y** are used as input terminals and which are used as output terminals.

To understand circuit operation, it is sensible engineering practice to assume, initially, that all the components used have ideal characteristics. Thus, the diode of **Fig. 2(a)** is considered 'ideal' if its voltage-current characteristic is described by two straight line sections, (i) and (ii) in **Fig. 2(b)**. As indicated in **Fig. 2(c)**, (i) represents an open circuit, or the open state of that switch. A slightly more realistic model is that giving sections (ii) and (iii) in **Fig. 2(b)**. These can be represented by the switch-battery combination in **Fig. 2(c)**. The battery, U_D, represents the forward voltage drop, assumed constant, of the diode when it conducts. Its value is about 1 V for high-power diodes and 0.7 V for low-power diodes.

Rectifier with resistive load

A basic full-wave power rectifier setup is shown in **Fig. 3(a)**. The input, from the secondary winding of a mains transformer, is connected to points **A** and **B**, and the load, in this case resistor R, is connected between points **X** and **Y**.

The transformer provides d.c. isolation, for safety, and, via the choice of the secondary/primary turns ratio, a means of stepping down the mains voltage without significant power loss.

As indicated in **Fig. 3(b)**, the 50 Hz sinusoidal secondary voltage is assumed to have a peak value of 15 V. At point **J**, $U_{AB} = +10$ V, corresponding to $t_1 = 2.3$ ms; at **K**, $t_2 = 12.3$ ms and $U_{AB} = -10$ V. As the usual assumption of a 'floating' output can be quite puzzling in an explanation of circuit operation for beginners, we will assume that **Y** is connected to a d.c. reference potential, U_r, and, in particular, that $U_r = +5$ V.

Referring to **Fig. 4**, the operation for ideal diodes and $U_{AB} > 0$ is as follows. Diodes D_2 and D_4 in opposite arms of the bridge conduct while D_1 and D_3 are cut off. Conduction in D_4 causes **B** to be held at U_r, so all the variations in secondary voltage appears at **A** and U_X follows U_A. Point J_1 on waveform

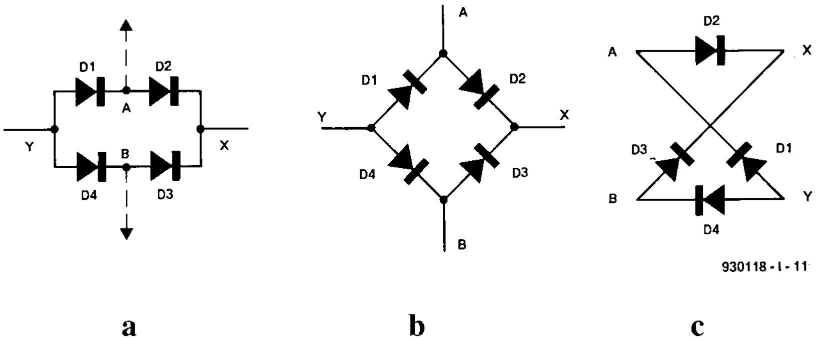


Fig. 1. (a) Bridge representation emphasizing diode polarity; (b) conventional pattern; (c) older 'figure-of-eight' pattern.

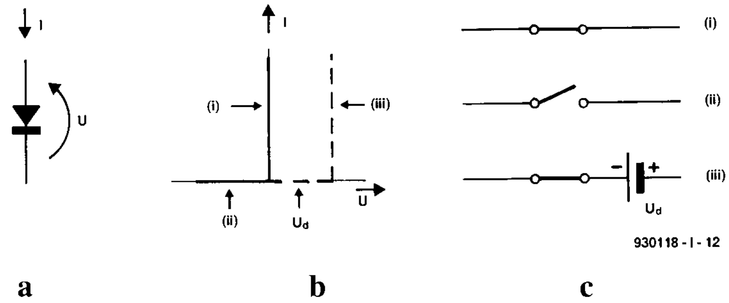


Fig. 2. Diode representation: (a) symbol; (b) current-voltage characteristic; (c) switch equivalents for (b).

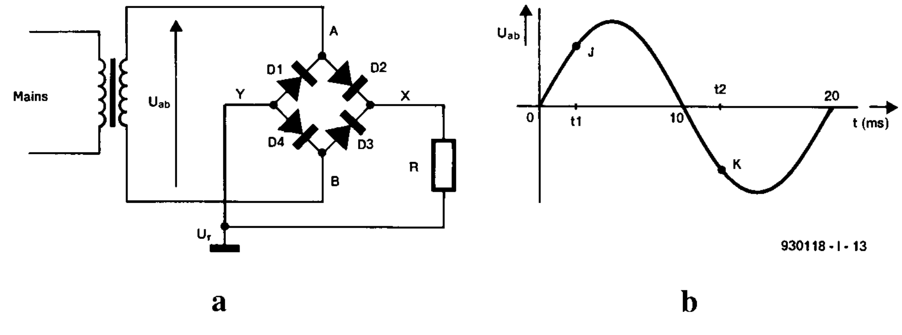


Fig. 3. (a) Bridge rectifier with resistive load; U_r = reference voltage; (b) waveform of transformer secondary voltage.

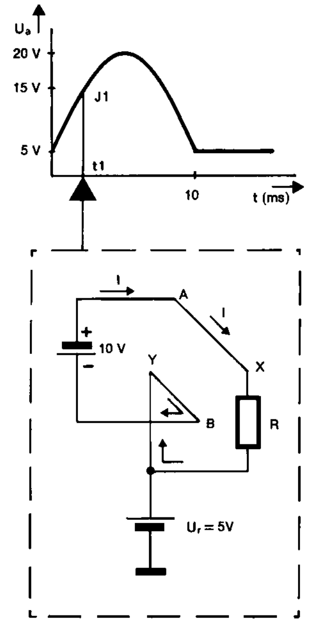


Fig. 4. Waveform for U_A. Boxed section shows instantaneous equivalent circuit at $t = t_1 = 2.3$ ms.

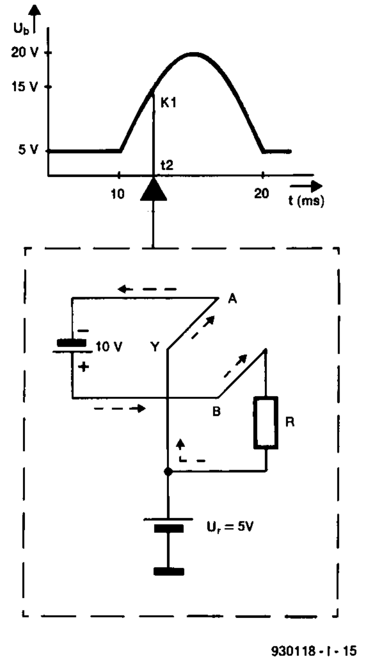
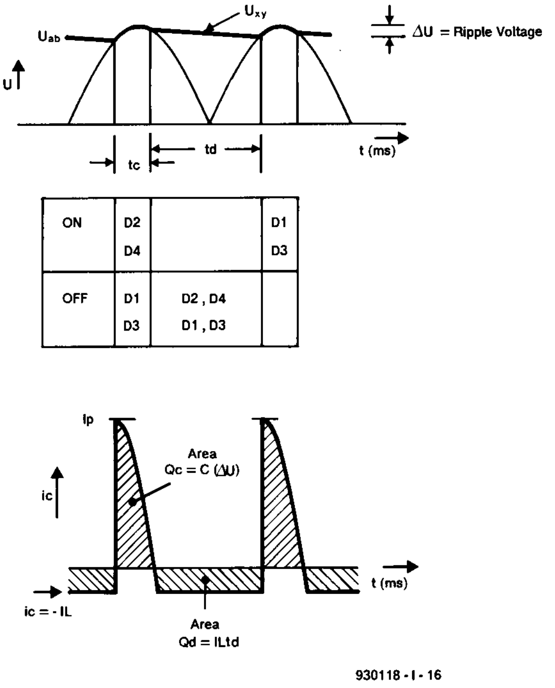


Fig. 5. Waveform for U_B. Boxed section shows instantaneous equivalent circuit at $t = t_2 = 12.3$ ms.



ON	D2 D4		D1 D3
OFF	D1 D3	D2 , D4 D1 , D3	

Fig. 6. Rectifier operation with a reservoir capacitor, C, in parallel with R; i_C = current flowing into C.

U_A corresponds to **J** —see **Fig. 3(b)**. An equivalent circuit for instantaneous circuit conditions at t_1 is shown in the boxed section of the diagram in **Fig. 4**. The arrows show the direction of current flow around the circuit. The peak inverse voltage (PIV) rating of each diode must exceed the peak input voltage, 15 V in this case.

Circuit operation for $U_{AB} < 0$ closely mirrors that for $U_{AB} > 0$ and is summarized in **Fig. 5**. In this case, D_1 and D_3 conduct while D_2 and D_4 are cut off; the direction of current flow is shown by the arrows on the broken lines. Conduction in D_4 now holds **A** at +5 V, while U_X follows U_B. Waveforms U_A and U_B are **not** sine waves and, with the present arbitrary choice of U_r = +5 V, neither has a negative section. However, U_{AB} (= $U_A - U_B$) **is** a sine wave. From the waveforms for U_X and U_Y in **Fig. 7(a)** and **7(b)**, we obtain U_{XY} (= $U_X - U_Y$) in **Fig. 7(c)**. The dotted lines show the output obtained when the voltage drop of practical diodes is taken into account.

Although U_X and U_Y in **Fig. 7(a)** and **7(b)** are dependent on U_r, it is significant that U_{XY} in **Fig. 7(c)** is not. Thus, the presence of U_r, introduced for explanatory purposes, is not fundamentally necessary for the production of U_{XY} in practice and can be dispensed with. In that case, the output is said to be 'floating'. More will be said about this later.

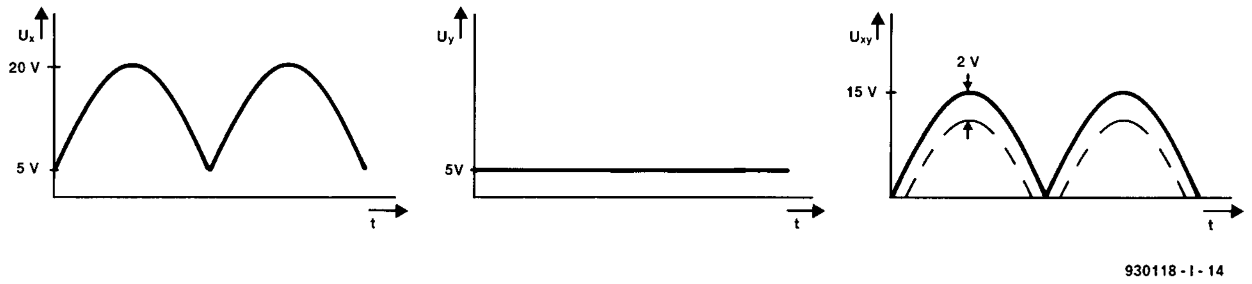
Use of a reservoir capacitor

The bold line in **Fig. 6** shows what happens to U_{XY} of **Fig. 7(c)** when a large reservoir capacitor, C, is connected across load resistor R. Waveform U_{XY} is that of U_{AB} with the gaps between the peaks almost filled in. There is only a 'ripple voltage', ΔU, which is normally small compared with the peak value, U_p. Current does not flow in opposite pairs of bridge diodes for half cycles of U_{AB}, but is limited to short intervals t_C in the vicinity of the peaks. During these intervals, the diodes supply a charge $Q_C = C\Delta U$ to C. Conduction ceases when U_{XY} is not able to fall as fast as U_{AB} when C is supplying the full load current, I_L, to R. The magnitude of the charge lost by C in intervals t_D is $Q_D = I_L t_D$. Since $t_D << T/2$, we can write $Q_D = I_L T/2$. Diode conduction recommences when the rising U_{AB} exceeds $U_p - \Delta U$.

After initial switch-on, a state of equilibrium as shown in **Fig. 6** exists when $Q_C = Q_D$.

Voltage ΔU decreases as C is made larger. However, larges values of C mean smaller values of t_C, higher amplitude current pulses and the requirement for more expensive diodes to cater for this.

For equipment design purposes, maximum values of (electrolytic) capacitor C are given in component catalogues that specify the rectification characteristics of bridge asemblies. As an example, consider a bridge rectifier for operation at 50 Hz and a load current that can range from 100 mA to 1 A. The maximum capacitance value is specified as 4700 μF. From these figures, we deduce that



a **b** **c**

Fig. 7. Other circuit waveforms: (a) U_X; (b) U_Y; (c) U_{XY}. Dotted lines show U_{XY} for finite diode drops.

$Q_{D(max)}$ = 10 (ms) × 1 (A) = 10 mC and Q_C = 4700 (μF) × ΔU = (4700 ΔU) μC, where ΔU is expressed in V. Equating Q_C and Q_D gives ΔU = 2.1 V (approx). This is the worst ripple case; for I_L = 100 mA, it is 0.21 V.

The simple hydraulic system in **Fig. 8** provides a graphic analogy for rectifier operation with a reservoir capacitor. The tank storing water is similar to the capacitor storing charge and the output pipe fulfils the role of the resistor. A human operator with a bucket, which can be refilled with water as required, plays the part of the transformer and diodes.

A quantity of water, Q_0, flows from the tank through the pipe as the liquid level falls from h_p to $h_p - \Delta h$. When the operator sees that the lower level is reached, he tips a quantity of water, Q_I, from the bucket into the tank. To restore the level to its original value, so that the process can be repeated continually, it is obviously necessary that $Q_I = Q_0$. To make the analogy with bridge operation closer, we should, of course, imagine two human operators with buckets who take it in turn to top up the tank!

Application in power supplies

In modern power supply units (PSUs), the bridge rectifier - reservoir capacitor combination is followed by a voltage regulator, a standard catalogue item, as shown in **Fig. 8**. Resistor *R* is no longer required: its role is taken over by the input circuit of the regulator. The function of the regulator is to reduce the ripple voltage to a negligible value and to produce a d.c. output voltage, U_{cc}, that does not vary by more than a few millivolts when its output current, I_L, changes from zero to its rated maximum value.

For correct operation, the regulator requires to operate above a specified minimum value of $U_{XY} - U_{cc}$, for instance, 3 V. Capacitance C_2, typically a parallel combination of a 10 μF electrolytic capacitor and a 0.1 μF disc capacitor, is used to supply current for load surges.

In **Fig. 8**, U_{cc} is 'floating' in the same sense that the battery voltage for powering a torch is floating. Thus, the potential difference between the terminals of the battery is fixed, but the potential difference between either of its terminals and earth is not.

A third terminal (E) is available on the instrument panel of the PSU in **Fig. 9**. It is connected, for instance via the metal of the casing, to the earth terminal of the mains socket. When used, it takes on the role of U_r discussed earlier. User options, for a single supply and two supplies, are shown in **Fig. 10**. Two PSU outputs may be stacked to produce a higher output voltage than is possible from a single supply. Note that not all commercially available low-cost PSUs have a floating output facility.

The advantages of a bridge rectifier over a conventional two-diode, full-wave rectifier setup are that the transformer is used more efficiently and does not need to have a centre tap. If a centre tap is available, the dual-polarity supply of **Fig. 11** makes a useful circuit arrangement for powering oper-

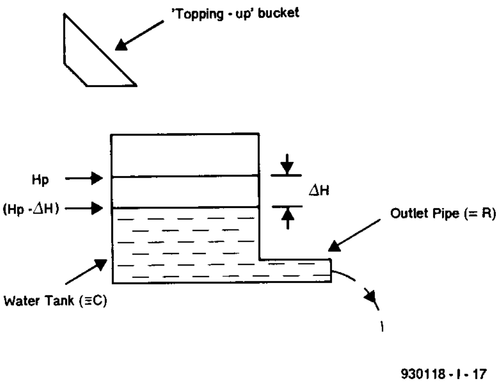


Fig. 8. Hydraulic analogy for Fig. 7.

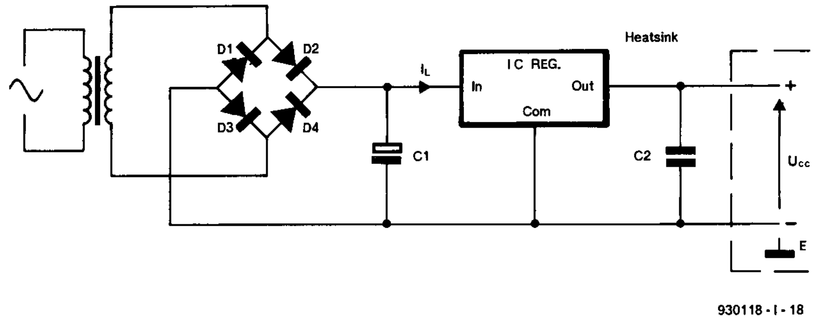


Fig. 9. A regulated PSU with 'floating' output.

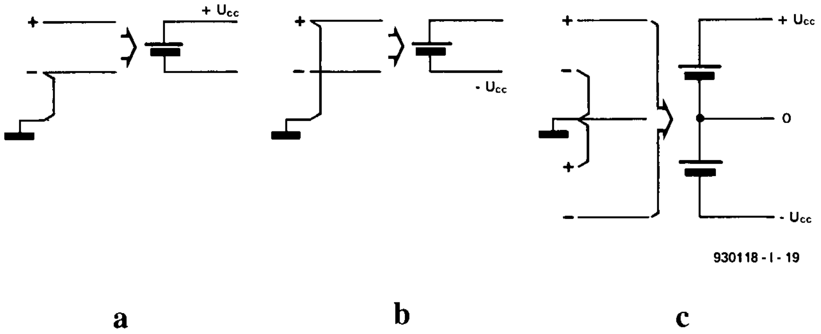


Fig. 10. User options for Fig. 9: (a) positive output; (b) negative output; (c) dual-polarity output with the use of two PSUs.

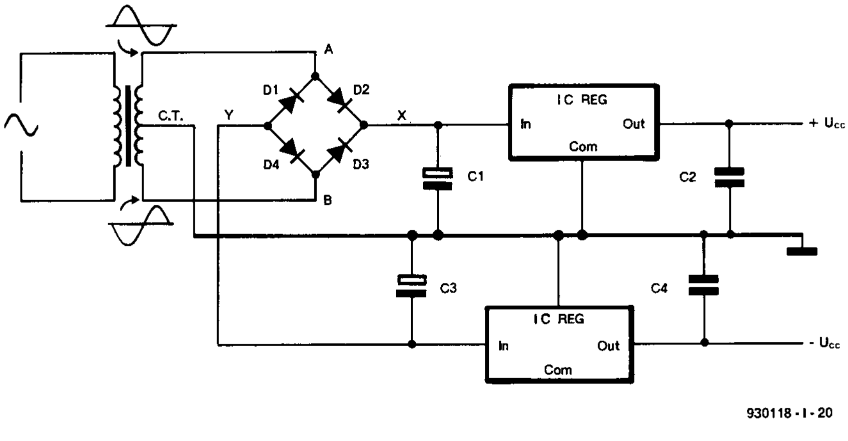
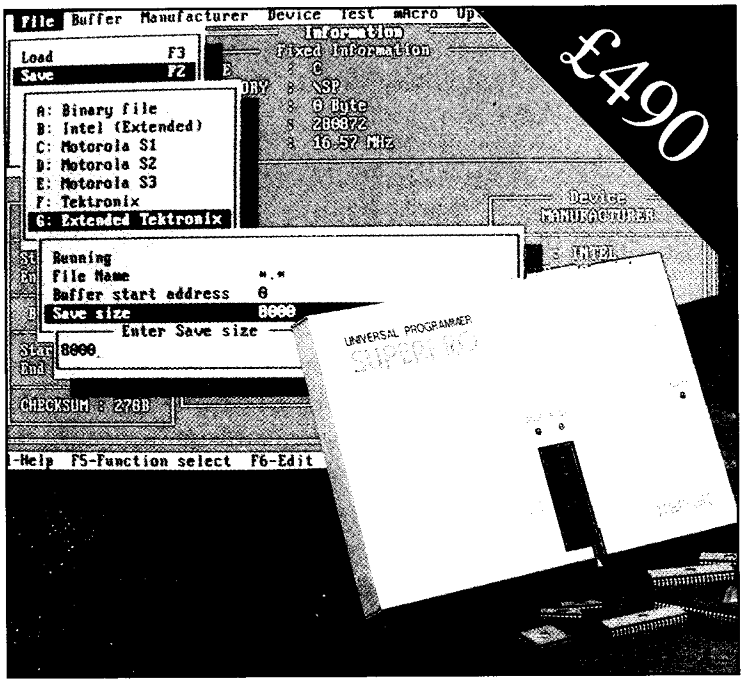


Fig. 11. Dual output PSU using a centre-tap transformer.

YOUR PERSONAL UNIVERSAL PROGRAMMER



Superpro is a low cost programmer which can easily be attached to your PC for use in R & D. It comes with its own half card for high speed communication so you can still use your parallel port.

Superpro comes from California so you can be sure the latest devices will be supported. In fact the software is updated on an almost monthly basis. The extensive device list covers most popular logic and memory families such as Amd's Mach series as well as the popular Altera range EP310 to EP1810. Support is also included for popular gals such as 16V8 and 20V8 from a variety of manufacturers. Standard 24, 28, 32 and 40 pin e (e) proms are also catered for in the 40 pin universal ZIF socket. An added bonus is the ability to program a range of microcontrollers. PLCC devices can be programmed with special adaptors.

So before spending thousands of pounds on a new stand alone programmer why not have a look at Superpro for a ten day trial period?

VISA Access MasterCard

LLOYD RESEARCH LTD 7/7A Brook Lane, Warsash, Nr Southampton,
Hants. SO3 9FH Tel: 0489 574040 for a device list

ational amplifiers.

Figure 12(a) shows an instantaneous equivalent circuit, analogous to that of **Fig. 4**, for $U_{AB} > 0$ and near its peak. Similarly, **Fig. 12(b)** is an instantaneous equivalent circuit, analogous to **Fig. 5**, for $U_{AB} < 0$ and near its peak.

In leaving the topic of power rectification, we note that finite voltage drops present no real problems. We can always obtain a higher secondary output voltage from the transformer to compensate from them as shown in the following example. Suppose:

$U_{cc} = 15$ V;
$U_{XY} - U_{cc} \geq 3$ V;
$\Delta U = 1$ V;
$U_D = 1$ V.

Then, taking into account two diode drops, the peak value of U_{AB} must exceed 22 V. A secondary winding providing 20 V_{rms}, corresponding to 28 V_{peak}, is appropriate.

In Part 2, we will consider instrument applications of the diode bridge. In such cases, it is usually constructed from discrete signal diodes.

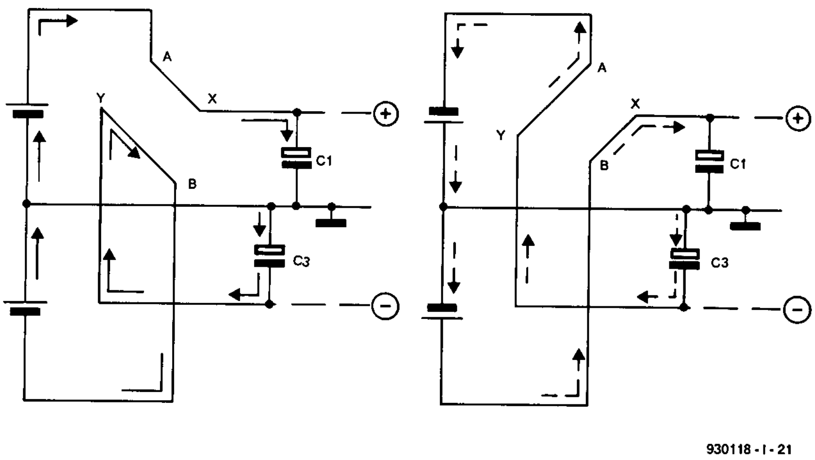
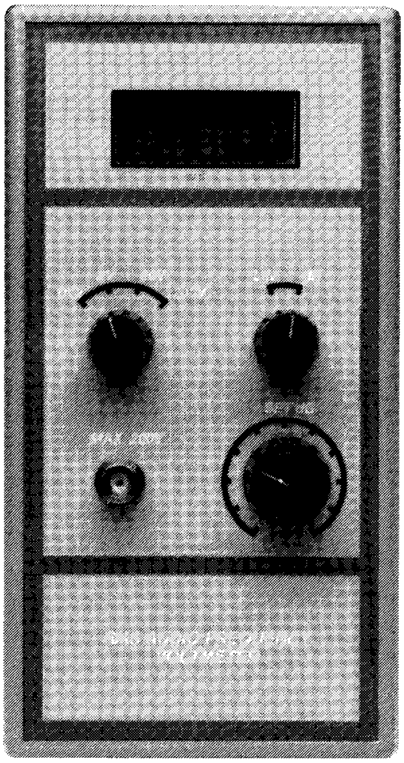


Fig. 12. Instantaneous equivalent circuits for U_{XY} near a peak: (a) $U_{AB} > 0$; (b) $U_{AB} < 0$.

RMS AF VOLTMETER

Design by F. Hueber

Since measuring alternating voltages and currents is not a straightforward matter, it is not to be wondered at that errors occur frequently. Non-sinusoidal measurands (quantities to be measured) in particular demand a fair knowledge and experience from the test engineer/technician. Most of the difficulties are caused by the fact that measuring instruments invariably only have a simple rectifier at their input. This is reasonably all right at very low frequencies, but even then, it does not take account of the shape of the measurand. Alternating voltages can be measured accurately only by a true-r.m.s. voltmeter, which unfortunately is a fairly expensive instrument. The instrument desribed in this article offers a viable and inexpensive alternative.



It is important to define precisely what has to be measured. The definition of the r.m.s. (root-mean-square) value of an alternating voltage is that value which in a resistive load produces the same amount of heat as a direct voltage of that value. For instance, an alternating voltage of 240 V_{rms} causes a lamp to light as brightly as a direct voltage of 240 V. The waveform of the alternating voltage is not important. A sinusoidal voltage of 240 V_{rms} has the same effect as a sawtooth-shaped, triangular or rectangular voltage of 240 V_{rms}. This means that the peak value of the alternating voltage is always higher than the r.m.s. value, except in the case of a square-wave voltage, whose r.m.s. value is equal to its peak value. Of a sinusoidal voltage, the ratio of the peak value to the r.m.s. value (called the **peak factor**) is $\sqrt{2}$ (= 1.414). Each and every shape of alternating voltage produces a different peak factor as shown in **Table 1**.

Since in most cases the r.m.s. value of a sinusoidal voltage is to be determined, in a standard multimeter a simple rectifier converts the alternating voltage into a direct voltage. The measured value is corrected by a **form factor** (1.11), and the result is shown on the meter. The form factor is the ratio of the r.m.s. value and the average value of the alternating voltage.

Since most multimeters are calibrated for sinusoidal voltages, an error will occur when a non-sinusoidal voltage is measured. These errors and some other information for a number of standard waveshapes are shown in **Table 1**. These data enable the true value of the measurand to be determined, but this neither very convenient nor, in many cases, precise.

Measuring true-r.m.s. values

True-r.m.s. meters use a special converter which makes complex arithmetical routines in the multimeter superfluous. The meaurand is applied to the converter, whose output is then a direct voltage that is representative of the r.m.s. value of the measurand. In other words, the IC assumes the entire complex conversion.

The output of the converter is calculated by sampling the input signal continuously. The value of the samples is squared and the average of the squared values over

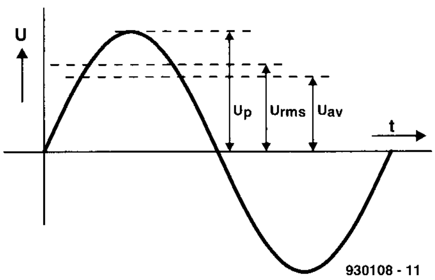


Fig. 1. A sinusoidal signal has three important values: p(eak), r.m.s. and av(erage).

Waveform U_{peak} = 1 V	Peak factor U_{peak} / U_{rms}	RMS value (V)	Reading on multimeter* (V)	Error with multimeter*(%)
sinusoidal	1.414	0.707	0.707	0
triangular	1.73	0.508	0.555	–2
white noise	3	0.333	0.266	–20.2
rectangular (d.f.† 1:1)	1	1.00	1.11	+11
rectangular (d.f.† 33:100)	2	0.25	0.25	–50
rectangular (d.f.† 1:100)	10	0.10	0.01	–99
sawtooth (d.f.† 1:1)	2	0.495	0.354	–28
sawtooth (d.f.† 1:4)	4.7	0.212	0.150	–30

†= duty factor
*= calibrated for sine waves

Table 1. Correlation between waveshapes and the ratios of their peak, r.m.s. and average values.

a certain period is computed. The root taken from this result is the true-r.m.s. value. This procedure is reliable as long as the period over which the average is calculated is long compared with the period of the measurand.

The converter used in the present meter is the AD636JH from Analog Devices. This inexpensive model in the range has a maximum error of 1%. A more accurate model is the AD636K (0.5%) but this is much more expensive.

True-RMS to d.c. conversion

Thermal r.m.s. to d.c. conversion

In theory, thermal conversion is a simple method; yet, in practice, it is difficult and expensive to implement. It involves comparing the heating value of an **unknown** a.c. signal to the heating value of a **known** calibrated d.c. reference voltage—see **Fig. 2**. When the calibrated voltage reference is adjusted to null the temperature difference between the reference resistor, R_2, and the signal resistor, R_1, the power dissipated in these two matched resistors will be equal. Therefore, by the basic definition of r.m.s., the value of the d.c. reference voltage will equal the r.m.s. value of the unknown signal voltage.

Each thermal unit contains a stable, low temperature coefficient resistor, R_1 and R_2, which is in thermal contact with a linear temperature-to-voltage converter, S_1 and S_2, an example of which would be a thermocouple. The output voltage of S_1 (S_2) varies in proportion to the mean square of V_{in}; the first order temperature/voltage ratio will vary as $K V_{in}/R_1$.

The circuit in **Fig. 2** typically has a very low error (about 1%) as wellas awide bandwidth. However, the fixed time constant of the thermal unit, R_1, S_1, R_2, S_2, limits the low-frequency effectiveness of this r.m.s. computational scheme.

In addition to the basic types discussed, there are also variable gain thermal converters available which can overcome the dynamic range limitations of fixed gain converters at the expense of increased complexity and cost.

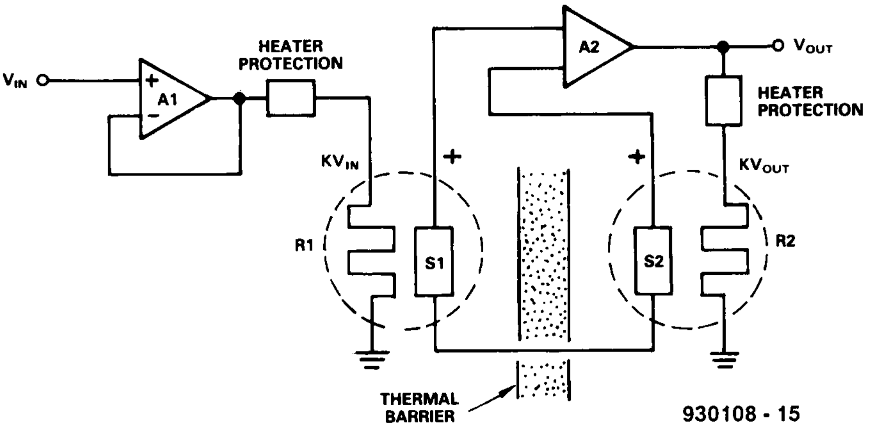


Figure 2.

Direct or explicit computation

The most obvious method of computing r.m.s. value is to perform the functions of squaring, averaging and taking the square root in a straighforward manner with multipliers and operational amplifiers. The direct or explicit method of computation (see **Fig. 3**) has a limited dynamic range because the stages following the squarer must try to deal with a signal that varies enormously in amplitude. For example, an input signal that varies over a 100:1 dynamic range (10 mV to 1 V) would have a dynamic range of 10,000:1 at the output of the squarer (squarer output = 1 mV to 10 V). These practical limitations restrict this method to inputs that have a maximum dynamic range of about 10:1. The system error may be as little as ±0.1% of full scale when a high-quality multiplier and square rooter are used. Excellent bandwidth and high-speed accuracy can also be achieved with this method.

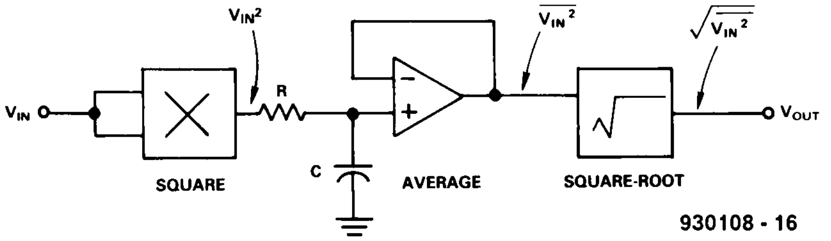


Figure 3

Indirect or implicit method

A generally better computing scheme uses feedback to perform the square root function implicitly or indirectly at the input of the circuit in **Fig. 4**. Divided by the average of the output, the **average** signal levels now vary **linearly** (instead of as the **square**) with the r.m.s. level of the input.This considerably increases the dynamic range of the implicit circuit as compared with explicit r.m.s. circuits.

Some advantages of implicit r.m.s. computation over other methods are fewer components, greater dynamic range, and generally lower cost. A disadvantage of this method is that it generally has a narrower bandwidth than either thermal or explicit computation. An implicit computing scheme may use direct multiplication and division (by multipliers), or it may use any of several log-antilog circuit techniques.

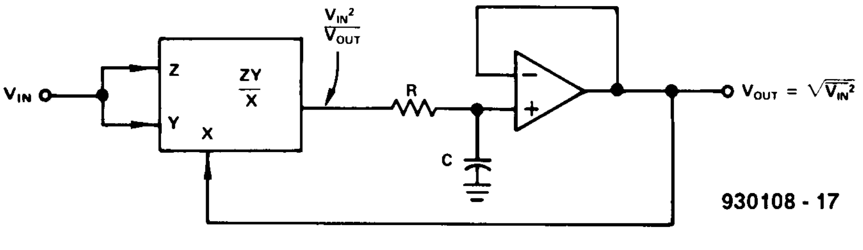

VIN
Z
Y
X
$\frac{ZY}{X}$
$\frac{V_{IN}{}^2}{V_{OUT}}$
R
C
–
+
$V_{OUT} = \sqrt{\overline{V_{IN}{}^2}}$
930108 - 17

Figure 4

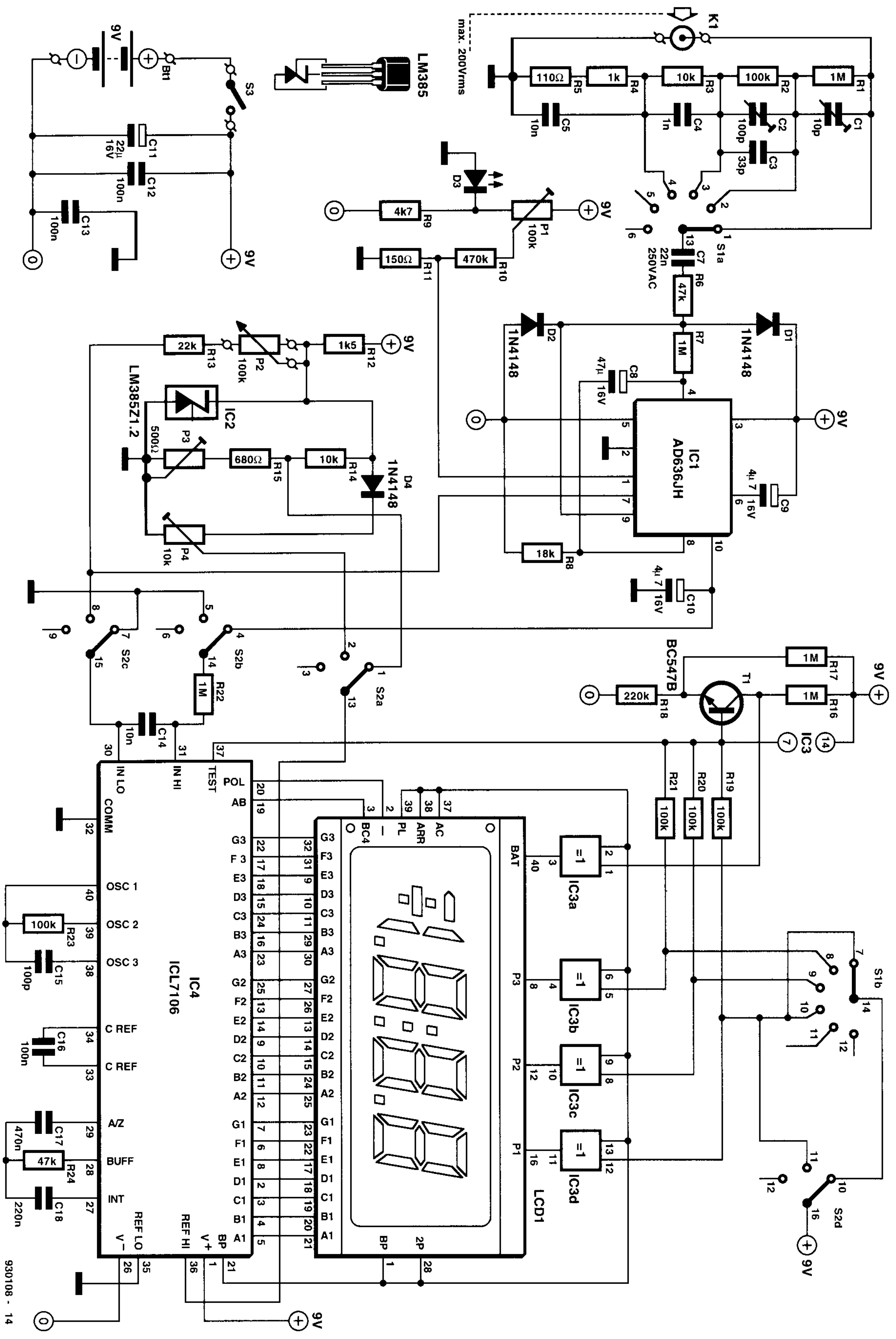
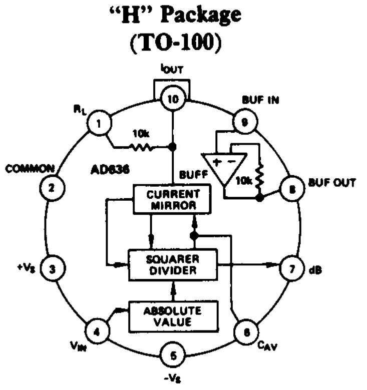


Fig. 5. Circuit diagram of the r.m.s. a.f. voltmeter.

The internal circuit of the AD636JH is shown in **Fig. 6**. The buffer operational amplifier may be used to lower the output impedance of the converter.



930108 - 12

Fig. 6. Internal circuit diagram of the AD636.

The circuit

The measurand is applied to the input stages via socket K$_1$—see **Fig. 5**. A frequency-compensated step attenuator, R$_1$–R$_5$, C$_1$–C$_5$, makes the level measurand suitable for the meter. It has four ranges: 200 mV; 2 V; 20 V; and 200 V.

The attenuated signal is applied to IC$_1$ via C$_7$ and a protection circuit consisting of R$_6$, D$_1$, and D$_2$. It is imperative that the rating of C$_7$ is as specified: a lower rating may cause the capacitor to be destroyed with all the consequences of this.

The buffer amplifier in IC$_1$ is used as an impedance inverter for the input signal, because the low resistance of the actual input (pin 4) at ±7 kΩ would load the attenuator too heavily.

Since the input impedance of A-D converter IC$_4$ is fairly high, the output signal of IC$_1$ can be taken directly to IC$_4$.

Capacitor C$_9$ aids the determination of the average voltage by IC$_1$.

Capacitor C$_{10}$ smooths any ripples in the output signal of the converter. It is essential for the correct operation of the meter that C$_8$, C$_9$, and C$_{10}$ are good-quality, low-leakage, preferably tantalum or **new** electrolytic, types.

The converter operates from a quasi-symmetrical supply. The common (pin 32) of IC$_4$, which is held at 2.8 V by an integral zener diode, is used as ground. The offset voltage at the output of IC$_1$ is compensated with P$_1$. Thus, when, after calibration, the input of the meter is short-circuited, the display will read 0.00 V. To prevent insufficient compensation when the battery is flat or nearly so, it is important that a stable voltage is used for the compensation. This is achieved by the use of a common red LED as a voltage source. If the battery voltage drops, the current through D$_3$ also drops, but the potential across it will not vary much. In any case, the current through the diode is so tiny, that it will hardly light.

Also required for correct operation is a stable reference voltage and this is provided by IC$_2$, a highly stable and temperature-compensated zener circuit. The reference voltage is 1.23 V which is brought down to 100 mV by R$_{14}$, R$_{15}$, and P$_3$. This voltage is applied to pin 36 of IC$_4$.

dB measurements

Often, for instance, for measurements on a.f. circuits (amplifiers, filters) there is a need for a logarithmic meter calibrated in dB rather than a linear meter. In antiquated test instruments that option was fairly simply implemented by adding a logarithmic scale to the display meter. In modern, electronic units this is not always so simple, Fortunately, IC$_1$ has a logarithmic output, pin 7. The voltage, $-\log U_{in}$, is derived from a transistor in the multiplier. This facility makes the conversion from a linear scale to a logarithmic one a simple matter. During logarithmic measurements, the display can be nulled as required with P$_2$. When the input level changes, the display instantly shows the measured value in dB with respect to the set level.

The circuit is switched from linear to logarithmic measurement with S$_2$. Since the logarithmic voltage is negative, the **b** and **c** sections of the switch are used to invert the polarity of the measurand with respect to IC$_4$. The **a** section provides a matched reference voltage at pin 36 of the A-D converter. The **d** section ensures that the decimal point of the display is in the correct position.

Since the logarithmic output voltage of IC$_1$ is temperature-dependent, the reference voltage must be compensated accordingly, which is effected with D$_4$. The reference voltage at P$_5$ is, therefore, also dependent on the ambient temperature.

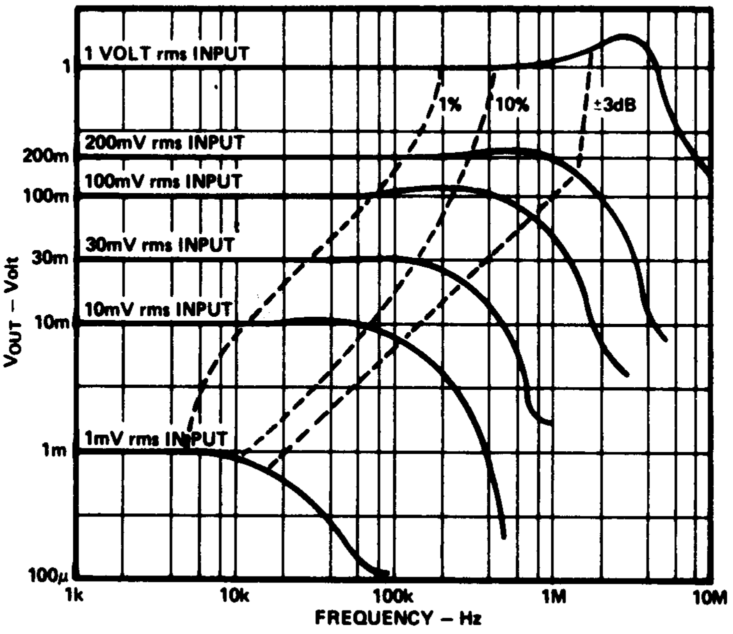
The dB measurements are possible in each range of the meter between +10 dB and –40 dB. For instance, in the 2 V range, the measurand varies between 6.32 V (+10 dB) and 0.02 V (–40 dB). Note that the sign in this range changes.

Frequency range

The calculation of the r.m.s. values of the measurand is carried out with the aid of an arithmetical circuit which makes use of logarithmic signals. As in all logarithmic circuits, the bandwidth is proportional to the signal level. The upper curve in **Fig. 7** (1 V$_{rms}$ input) shows the near-ideal behaviour of the r.m.s. converter. The dashed lines show the upper frequency limits for 1%, 10% and ±3 dB of reading additional error. For example, note that a 1 V$_{rms}$ signal will produce less than 1% of reading additional error up to 220 kHz. A 10 mV$_{rms}$ signal can be measured with 1% of reading additional error (100 µV) up to 14 kHz. This means that the level of high-frequency measurands should be as high as possible. At the lower limit, linearity is guaranteed to about 30 Hz; if a small error is acceptable, even down to 10 Hz. At very low frequencies, the bootstrap circuit keeps the measuring error down to about 0.2% or ±0.2 dB.

Construction

The display is a standard application of the ICL7106. The 'low battery' indicator, provided by T$_1$, becomes active when the volt-



930108 - 13

Fig. 7. The bandwidth of the converter is proportional to the level of the input signal.

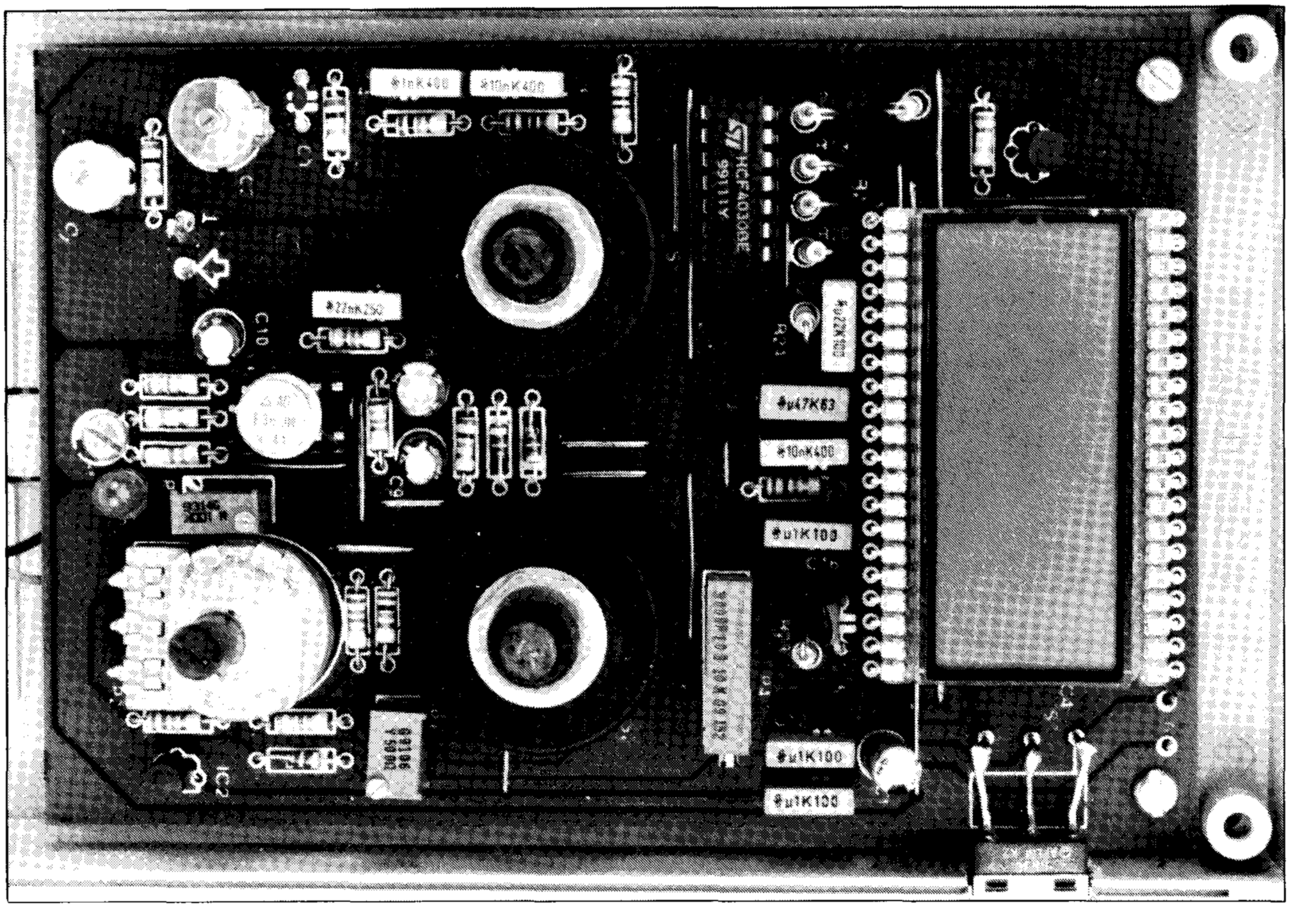


Fig. 8. Inside view of the completed r.m.s. a.f. voltmeter.

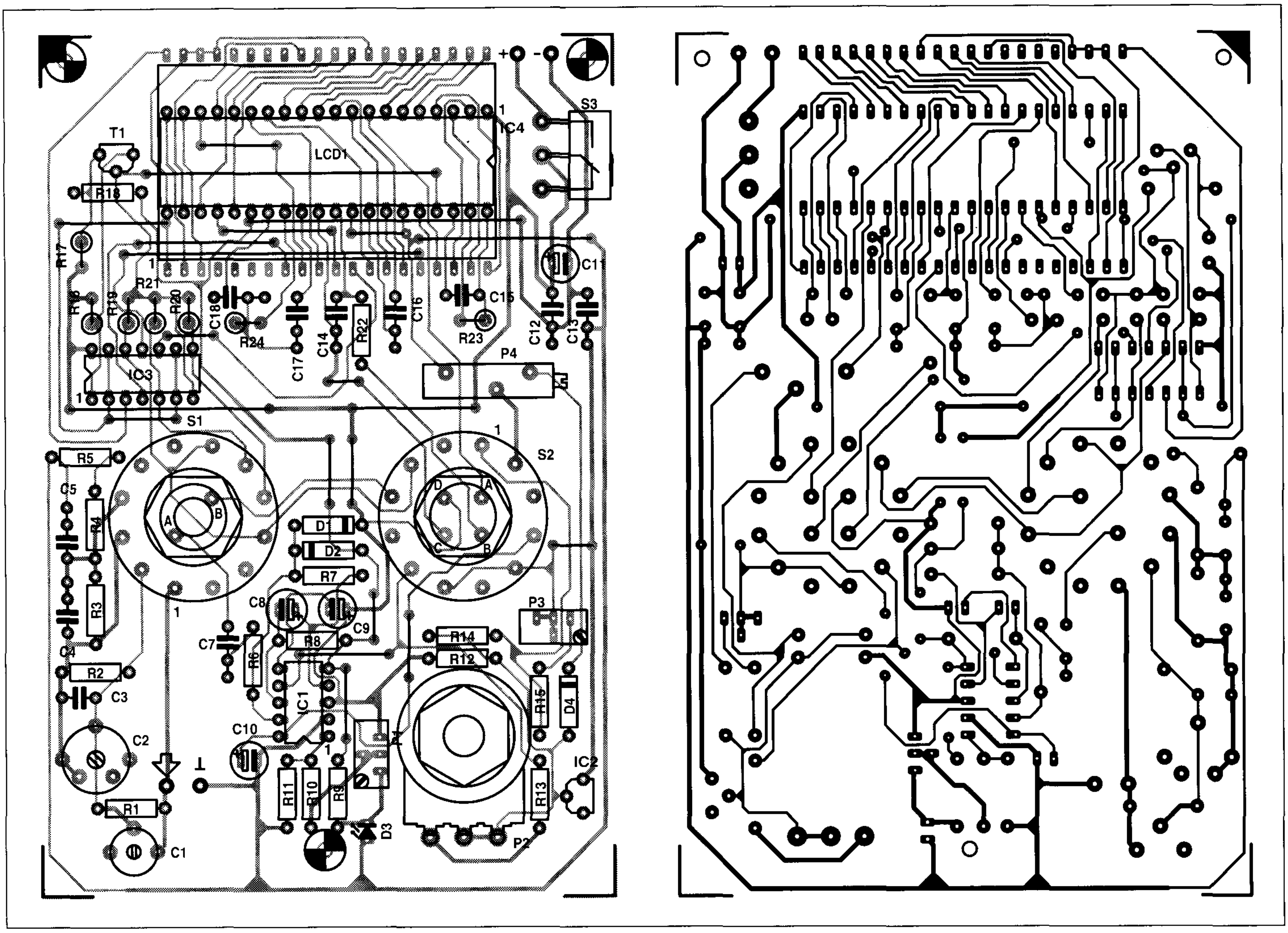


Fig. 8. Printed-circuit board for the r.m.s. a.f. voltmeter.

age drops to 6.5–7 V. Since the entire circuit draws only about 3 mA, a 9 V battery will last quite a time.

The meter is best built on the single-sided printed-circuit board shown in **Fig. 8**. Apart from the BNC input socket and the battery, all components are housed on the board.

Start construction by laying the many wire bridges. The LCD is located above IC_4, and it should therefore be fitted in a good-quality socket. In case of trouble, IC_4 will then remain accessible.

Switch S_3 is a right-angle slide type so that its knob is located at the side of the meter.

Mount rotary switches S_1 and S_2 directly on to the board: these controls must be supported by the lid of the housing to prevent undue mechanical stress on the board. This means that the holes through which the spindles protrude must be a tight fit. Make sure that the rings that determine the number of positions are in the correct position, otherwise the switch may be set to an undefined position.

It is important that the specified resistors and capacitors are used for the voltage divider. Different types may cause trouble when high voltages are applied to the attenuator.

Also important is that the connection between the BNC socket and the board is made from medium-duty cable. Should this cable be too thin, flash-over may occur when the input voltage rises to 200 V_{rms}.

Testing & calibration

Set S_2 to position LIN(ear) and S_1 to the 2 V range. Short-circuit the input. Adjust P_1 till the display reads '000'.

Apply a sinusoidal signal of about 80 Hz at a level of 1.8 V_{rms} both to the input of the meter and to that of a (good-quality) multimeter. The two instrument should give the same reading. If not, adjust P_3 until the two readings are identical.

Next, increase the signal frequency to 20 kHz and adjust C_1 until the two readings are the same again.

Then, set S_1 to the 20 V range and carry out the same tests as above. The reading in this case should be $^1/_{10}$ of the input, that is, 180 mV_{rms}. If the meter readings are different at 20 kHz, adjust C_2 till they are the same again. Since the settings of C_1 and C_2 affect one another, it is necessary for the foregoing tests to be repeated a couple of times.

Set S_2 to position dB and S_1 to position 2 V. Apply an alternating signal at a level of 2 V to K_1 and adjust P_2 until the display reads '000'. Then, set S_1 to position 20 V and adjust P_4 until the display reads –20 dB. This completes the calibration.

Parts list

Resistors:
R_1 = 1 MΩ, 1%
R_2 = 100 kΩ, 1%
R_3 = 10 kΩ, 1%
R_4 = 1 kΩ, 1%
R_5 = 110 Ω, 1%
R_6, R_{24} = 47 kΩ
R_7, R_{16}, R_{17}, R_{22} = 1 MΩ
R_8 = 18 kΩ
R_9 = 4.7 kΩ
R_{10} = 470 kΩ
R_{11} = 150 Ω
R_{12} = 1.5 kΩ
R_{13} = 22 kΩ
R_{14} = 10 kΩ
R_{15} = 680 Ω
R_{18} = 220 kΩ
R_{19}, R_{20}, R_{21}, R_{23} = 100 kΩ
P_1 = 100 kΩ preset, upright type
P_2 = 100 kΩ preset
P_3 = 50 Ω preset, upright type
P_4 = 10 kΩ preset, horizontal type

Capacitors:
C_1 = 10 pF trimmer
C_2 = 100 pF trimmer
C_3 = 33 pF
C_4 = 1 nF
C_5, C_{14} = 10 nF
C_7 = 22 nF, 250 V a.c.
C_8 = 47 μF, 16 V, radial
C_9, C_{10} = 4.7 μF, 16 V, radial
C_{11} = 22 μF, 16 V, radial
C_{12}, C_{13}, C_{16} = 100 nF
C_{15} = 100 pF
C_{17} = 470 nF
C_{18} = 220 nF

Semiconductors:
D_1, D_2, D_4 = 1N4148
D_3 = 5 mm LED, red
T_1 = BC547B

Integrated circuits:
IC_1 = AD636JH
IC_2 = LM385Z1.2
IC_3 = 4030
IC_4 = 7106

Miscellaneous:
K_1 = BNC socket for PCB mounting
S_1 = 2-pole, 6-position rotary switch
S_2 = 4-pole, 2-position rotary switch
S_3 = shift switch, right-angle, for PCB mounting
LCD_1 = $3^1/_2$ digit LCD Type LTD221F12
Bt_1 = 9 V battery with clip
Enclosure Pac-Tec Type HPL9VB (available from OK Industries, Unit 1 Deacon Trading Estate, Eastleigh SO5 5RR. Telephone (0703) 619 841.
PCB No. 930108, see p. 110
Front panel foil No. 930108F (p. 110)

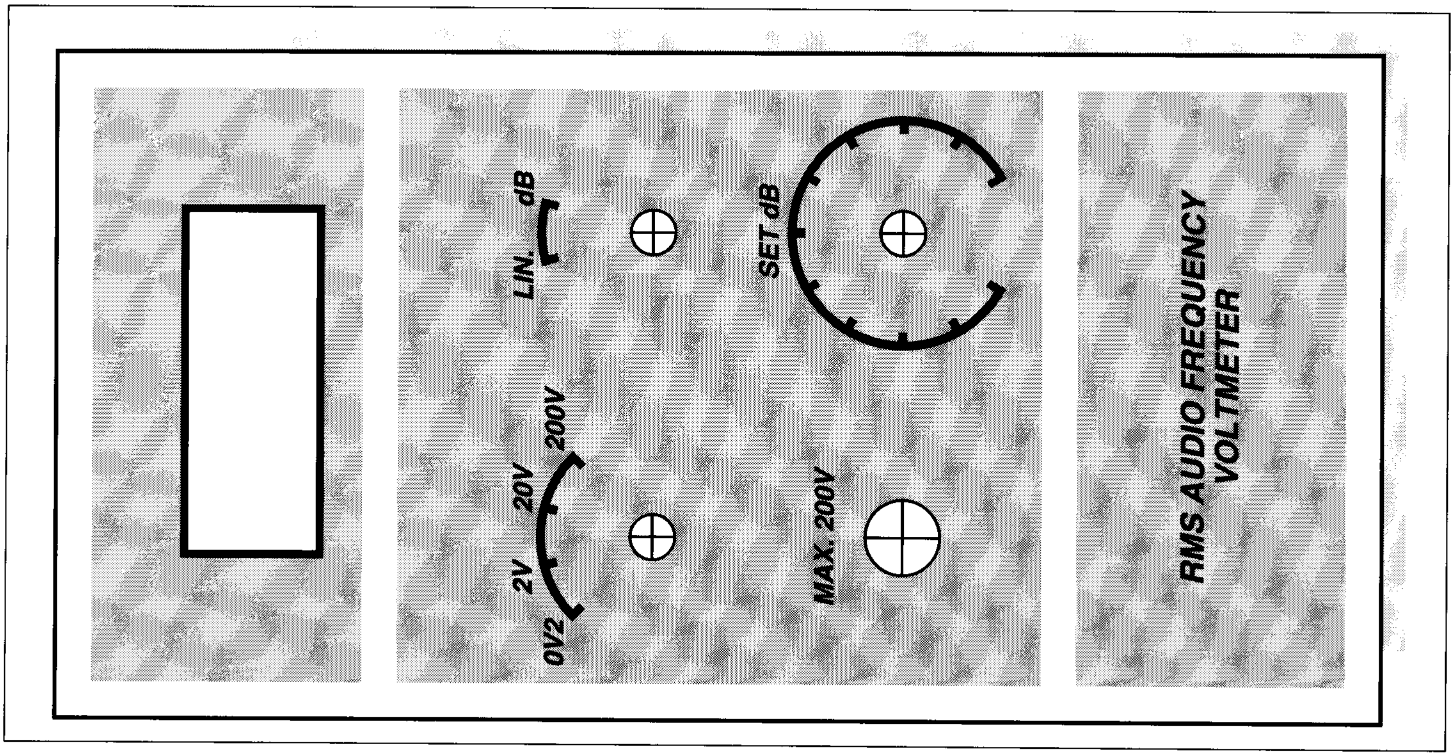


Fig. 9. Front panel foil for the r.m.s. a.f. voltmeter.

PWM MOTOR CONTROL

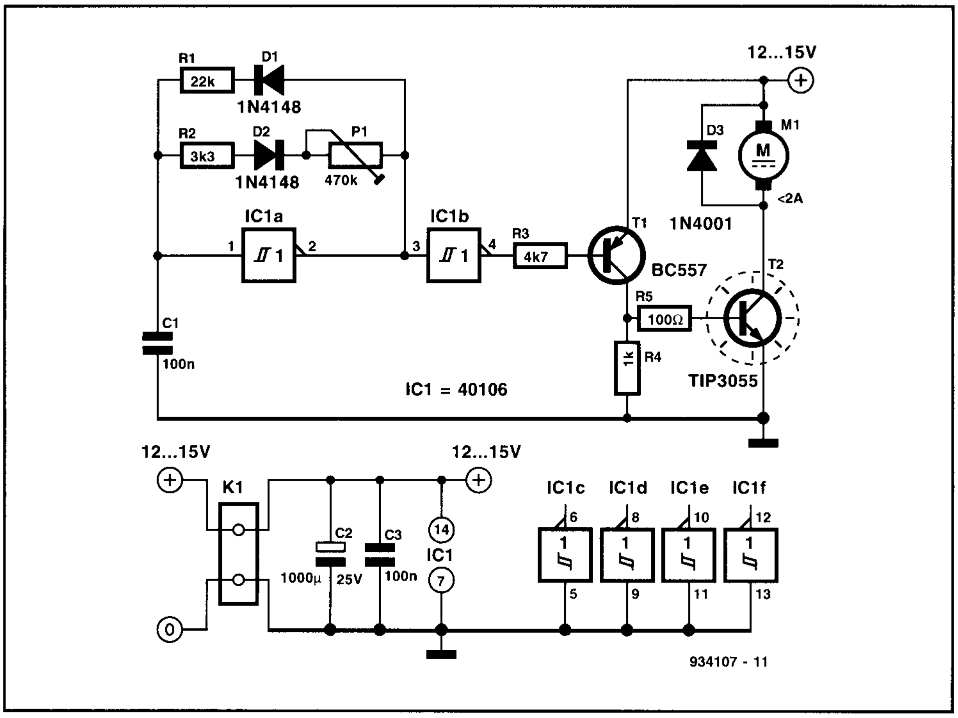
Pulse width modulation (PWM) is ideal for controlling small electric PCB drills that draw currents of up to 2 A. Larger currents are possible if T$_2$ gets addtional cooling and the value of C$_2$ is increased. The design also makes use of the fact that the drill works with a small d.c. motor whose rotary speed is a fucntion of the voltage across it.

The design is based on a Type 40106 astable multivibrator, IC$_{1a}$, whose output is low for a period determined by R$_1$ and high for a period set by R$_2$ and P$_1$.

When C$_1$ is discharged, the level at the input of IC$_{1a}$ is below the lower threshold, so that the output of this stage (pin 2) is high. The capacitor is then charged rapidly via D$_1$ and R$_1$, and reaches the upper threshold in about 1.5 ms. The output of IC$_{1a}$ then goes low, whereupon C$_1$ discharges via D$_2$, R$_2$ and P$_1$. In the prototype, the discharge time could be set between 0.2 ms and 25 ms. This means that the duty factor of the output signal may be varied between 5% and 90%.

The signal is inverted again and then applied to the base of T$_1$. Transistors T$_1$ and T$_2$ are switched on, and the motor is energized, during the negative period of the output pulse of IC$_{1b}$ (pin 4). When the resistance of P$_1$ is at a minimum, the rotary speed of the drill motor is at a maximum.

[Amrit bir Tiwana - 934107]



FREQUENCY-OPERATED SWITCH

Voltage-operated switches are fairly commonplace, but frequency-operated ones are still rare. The one described here is based on a 4046, a PLL (phase-locked loop) that, internally, is largely digital.

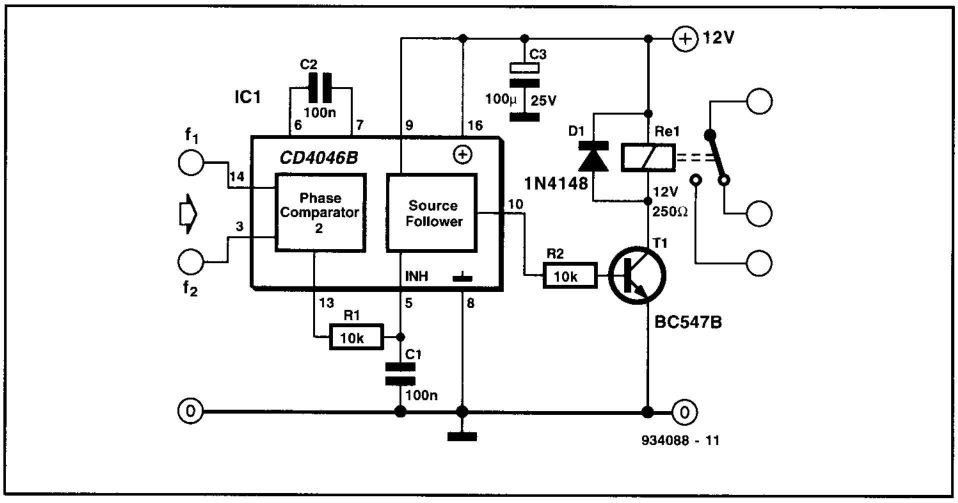
The two frequencies that are to be compared are applied to pins 3 and 14 of IC$_1$. They must be rectangular with an amplitude equal to the supply voltage of 3–5 V. Their duty factor is not important, since the IC reacts only to leading transitions (edges). If f_1 is lower than f_2, the output goes low. If $f_1 = f_2$, a rectangular voltage, whose duty factor is stable and determined by the phase difference of the two signals, is present at pin 13. This voltage is converted into a direct voltage by R$_1$ and C$_1$, which is then applied to switching transistor T$_1$ via the source follower. If the voltage level is high enough, T$_1$ will switch on and energize the relay.

In theory, the error rate of the switch is 0, but in practice 0.1% must be allowed. The time constant R$_1$-C$_1$ must be about 10 times as long as the period of the input signal. Higher ratios delay the operation unnecessarily.

When the frequencies are almost identical, it may, in the worst case, take one period of the difference frequency before the circuit is enabled.

The circuit is suitable for operation from 3–15 V supplies, but make sure that the supply and relay voltages are the same. Transistor T$_1$ can switch up to 100 mA. The current drawn is about 0.5 mA plus the relay current.

[I.M. Nagarajan - 934088]



WINDSCREEN WIPER CONTROL

The circuit and the associated software form a quasi-intelligent windscreen wiper interval for cars. Although intended for the 80C32 single-board computer described in **Ref. 1**, the hardware and software should be usable with any 8051 or 8032 based microcontroller system.

The hardware consists basically of a press-key, S_1, and three transistor drivers — two to drive the LEDs, and one to drive the windscreen wiper relay fitted in the car. D_2 is the wiper control on/off indicator, and D_3 the wiper motor on /off indicator.

After the control has been switched on, the LED and relay control bits, P1.0 and P1.1, are cleared, and the processor enters a wait loop after a 130 ms delay. This delay serves to debounce the press-key, which is connected to port line P1.1. As soon as the key is pressed, the on/off bit, P1.0, is set, and D_2 lights. If the key is pressed for less than 1 s, the program defaults to a wiper interval of 6.5 s (32H × 130 ms). If the key is pressed for longer than about 1 s, the wiper interval takes the 'key pressed' time as the new interval time.

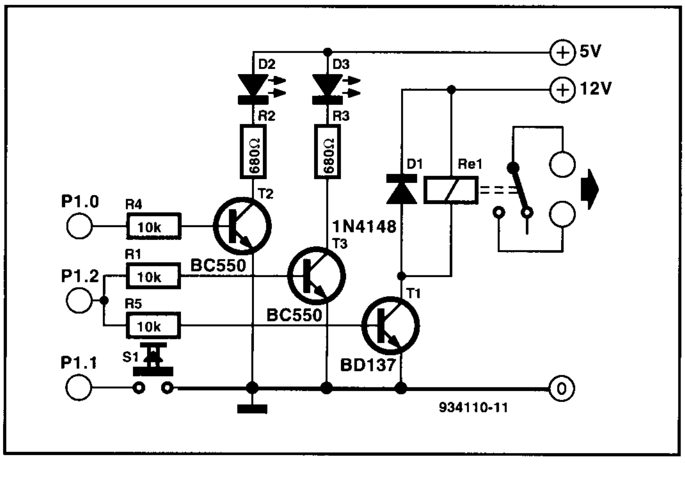
Once a key action has been detected (KEYO loop), the accumulator value is increased from 0 in 0.13 s steps until the key is released, whereupon the counter value is written to register R7. Next, the accumulator value is compared (by subtraction) with a preprogrammed value of about 1 s (8 × 0.13 s). If it is smaller, the carry flag is set, and the accumulator is loaded with the value contained in R6. This results in a (default) wiper interval of about 6.5 seconds.

When the key is pressed for longer than 1 s, R6 is loaded with the stored value via R7 and the accumulator (NEW TIME). The new interval then corresponds roughly to the time the key was held pressed. When the key is pressed again, the program reverts to start. If the key action is short (<1 s), one last wiper action takes place in the previously programmed interval time. If the key action is long (>1 s), this is taken to mean a new interval time. In this way, the wiper interval may be adapted quickly to the amount of rain on the windscreen.

(J. Borm – 934110)

Reference:

1. Radio data system (RDS) decoder. *Elektor Electronics* February 1991.



```
; Wiper interval
; press-key connected to P1.1
; on/off LED         to P1.0
; relay              to P1.2 (buffered)

; definitions of SFR's
A           EQU    0E0H
R0           EQU    000H
R1           EQU    001H
R2           EQU    002H
R7           EQU    007H
R6           EQU    006H
P1          EQU    090H

; definition of port pins
LED          EQU    090H
KEY          EQU    091H
RELAY          EQU    092H
            ORG    00H

; Store default interval in R6 (approx. 10 seconds)
            MOV    R6, #32H

; Initialize accumulator and hardware
START          MOV    A, #0
            CLR    LED
            CLR    RELAY

; software debounce of switch approx. 130ms
            MOV    R0, #0H
TIME0         MOV    R1, #0H
TIME1         DJNZ   R1, TIME1
            DJNZ   R0, TIME0

; wait until key pressed i.e. KEY=0
KEY0         JB     KEY, KEY0

; key pressed, power LED on
            SETB   LED

; start counting until key released (measurement interval)
KEY1         INC    A
; time loop 130ms
            MOV    R0, #0H
TIME2         MOV    R1, #0H
TIME3         DJNZ   R1, TIME3
            DJNZ   R0, TIME2
; key released?
            JNB    KEY, KEY1

; store value (A x 130ms) in R7
            MOV    R7, A
            CLR    C

; compare value with minimum interval time (approx. 1s)
            SUBB   A, #08H      ; 8 x 130ms
            JNC    NEW_TIME    ; >1s, new value, else default
WIPE         MOV    A, R6
PULSE         MOV    R0, #0H
TIME4         MOV    R1, #0H
; keep checking if key pressed (i.e. wiper off)
            JNB    KEY, START1
TIME5         DJNZ   R1, TIME5
            JNB    KEY, START1
            DJNZ   R0, TIME4
            JNB    KEY, START1
            DEC    A
            JNZ    PULSE
; switch on relay (fixed interval)
            SETB   RELAY
            MOV    R0, #8
TIME6         MOV    R1, #0H
TIME7         MOV    R2, #0H
            JNB    KEY, START1
TIME8         DJNZ   R2, TIME8
            JNB    KEY, START1
            DJNZ   R1, TIME7
            JNB    KEY, START1
            DJNZ   R0, TIME6
; switch off relay
            CLR    RELAY

            JB     KEY, WIPE
START1         JNB    KEY, START1
            AJMP   START

; update interval time
NEW_TIME      ADD    A,#08
            MOV    A, R7
            MOV    R6, A
            SJMP   WIPE

            END              934110-12
```

BICYCLE LIGHT WITH AFTERGLOW

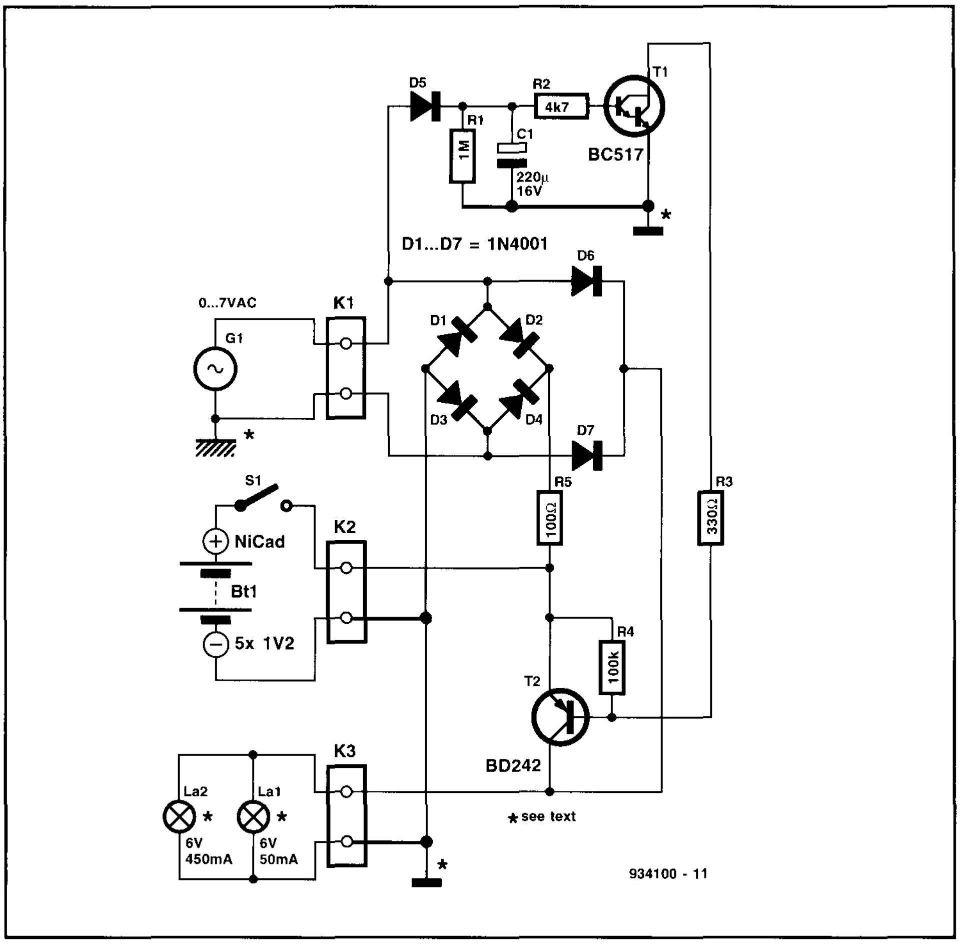
The circuit presented here ensures that bicycle lights remain on for a little while after the bicycle (and thus the dynamo) has come to a standstill. It has the disadvantage that the frame of the bike cannot be used as the common return: a separate wire has to be run for this. This is because use is made of a bridge rectifier to provide full-wave rectification of the dynamo voltage. Consequently, the alternating and direct voltages must float with respect to one another.

Actually, bridge rectifiers are used that have one half in common. Diodes D_1–D_4 constitute the bridge via which (and R_5) the NiCd battery is charged when the bicycle is moving (and the dynamo is connected). Diodes D_1, D_3, D_6, and D_7 form the bridge via which the bicycle lights are powered when the dynamo voltage is sufficiently high.

When the dynamo is driven, C_1 is charged via D_5, which causes T_1 to conduct. If T_1 is on and the dynamo output drops below a certain level, T_2 is switched on, whereupon the bicycle lights are powered by the NiCd battery.

When the bicycle is at a standstill and the dynamo is no longer driven, C_1 is no longer charged. Because of this, T_1 will gradually stop conducting and this will also switch off T_2. The bicycle lights will then go out.

Switch S_1 serves to prevent the NiCd battery slowly discharging via the circuit when the bicycle is not used. The switch should then be opened.



If the afterglow time is found too short, it may be lengthened by increasing the value of C_1.

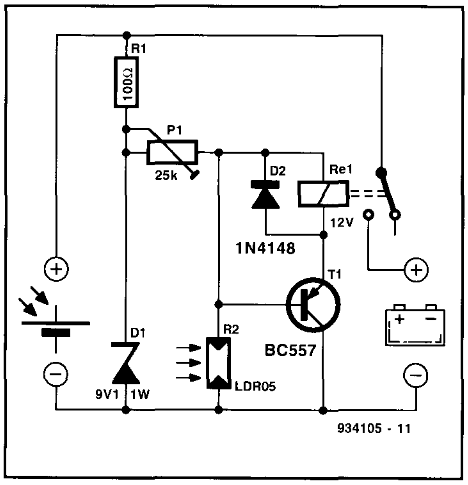
[L. Pijpers - 934100]

SOLAR PANEL SWITCH

When a battery is charged by a solar panel during the day, it may discharge via that panel after sunset. This may, of course, be prevented by a diode, but that has the drawback of a forward voltage drop of 0.7 V or, in the case of a Schottky diode, 0.4 V. In many applications, this is not acceptable.

The present circuit replaces the diode and connects the solar panel to the battery via a relay contact. It is powered by the solar panel. When the supply voltage is too low, the relay is not energized so that the battery is not connected to the solar panel.

When the panel output is sufficient to energize the relay and the LDR (R_2) receives enough light to cause T_1 to conduct, the relay is energized and the battery will be charged.



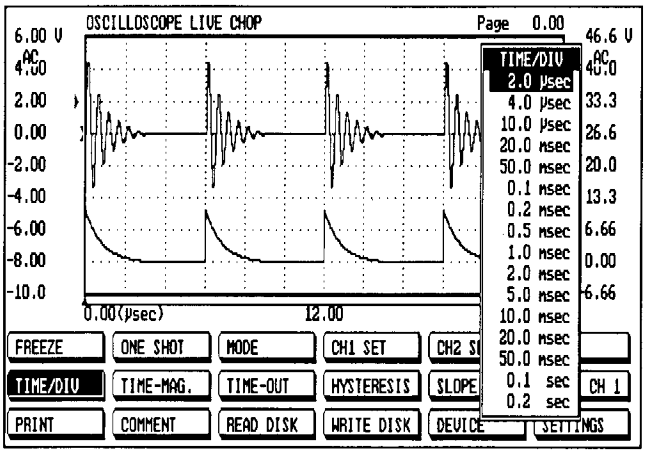
Owing to its inherent hysteresis, the relay will remain energized even if the potential across the panel drops somewhat. A connected and charged battery cannot actuate the relay when the light begins to fail, because the LDR will then switch off T_1. At what brightness that occurs may be preset with P_1.

Since the current drain is determined primarily by the relay, it is important that this is a miniature type with a high coil resistance, which can nevertheless switch up to 10 A (for instance, Siemens Type V23037-A0002-A101*).

[L. Lemmens - 934105]

* Siemens product. Available from ElectroValue, Unit 3, Central Trading Estate, Staines, Middx TW18 4UX. Telephone: (0784) 442253. Fax: (0784) 460320.

DATA ACQUISITION WITH THE PC



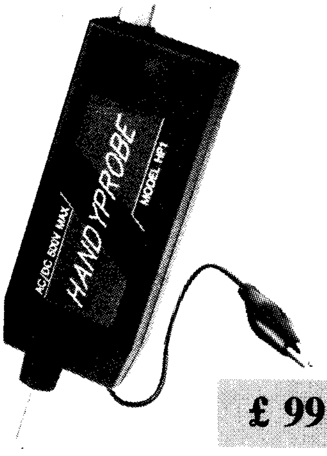
TiePie engineering manufactures a complete range of computer-controlled measuring instruments. Connecting these units to a PC (MS DOS 3.0 or higher) results in a number of comprehensive test instruments:

- oscilloscope;
- voltmeter;
- spectrum analyzer;
- frequency meter;
- transient recorder.

All measured data can be stored on disk or run off for documentation. Because of the many trigger possibilities, a variety of signals can be measured, while the powerful software enables a multitude of measurements to be carried out in a straightforward manner. Application areas include: service; medical research; automatic test systems; research and development; and education.

LOW COST: HANDYPROBE

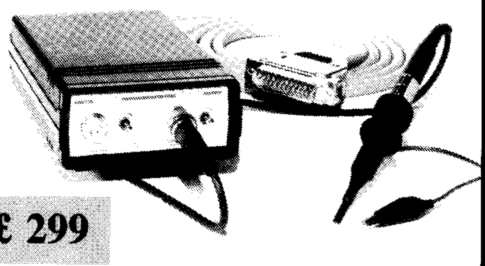
Connect the HANDYPROBE to the parallel printer port of the PC and start the software. Measuring can be carried out at once. The HANDYPROBE does not need an external power supply. Some technical parameters: 0.5-400 V software select input range; one input channel; 8 bits resolution (overall accuracy 2%); A complete software program consisting of a digital storage oscilloscope, spectrum analyzer, voltmeter and a transient recorder is provided. The HANDYPROBE is eminently suitable for servicing and educational purposes.



£ 99

BEST PERFORMANCE: HANDYSCOPE

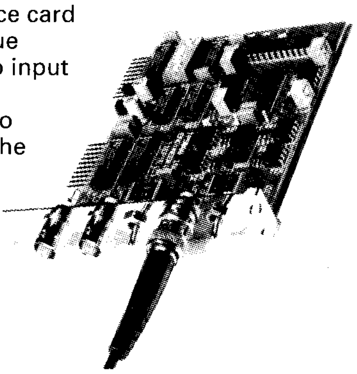
The HANDYSCOPE is connected to the parallel printer port. This makes it possible to carry out measurements with a laptop or notebook PC. Because of its high resolution (12 bits), the HANDYSCOPE is a very accurate instrument. The measuring rate is 100,000 samples/sec. Either of the two channels can be set independently over a range of 0.5-20 V (with a 1:10 probe up to 200 V). The advanced software enables many measurements to be carried out. Two probes (switchable 1:1-1:10) are provided. The HANDYSCOPE is constructed as a small table model with two BNC connectors. The length of the cable linking the PC and the HANDYSCOPE is 1.8 m, which can be extended to 3.8 m.



£ 299

MULTIFUNCTIONAL: TP5008

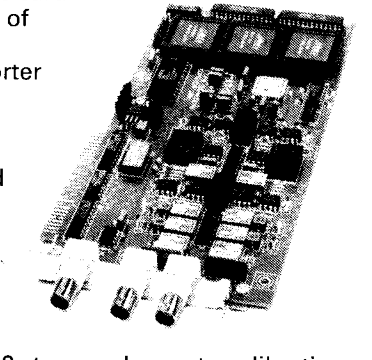
The TP5008 is an interface card that provides an analogue output in addition to two input channels. This output in combination with the two inputs may be used for the setting up of a complete control loop. The output may also be used as a function generator. The TP5008 has a resolution of 8 bits and a sampling rate of 200,000 samples/sec (200 kHz). The input range may be set to 0.5-20 V full-scale deflection. The output range covers 1.25-2.5 V. The TP5008 is fitted with BNC connectors and is delivered complete with a user manual and software. Separately available are 1:1-1:10 probes and 1:100 oscilloscope probes.



£ 197

VERY HIGH SPEED: TP208

The TP208 is an interface card with a measuring speed of 2×20 Megasamples/sec (8 bits). Phenomena shorter than one millionth of a second can still be measured well. The completely digitized triggering ensures very stable triggering with many trigger possibilities. The TP208 has an input range of 5 mV/div to 20 V/div in 12 steps and an auto calibration function. Since both channels may be sampled simultaneously, phase differences can be measured very accurately. Even single phenomena can be measured since each channel has a 32 KByte memory. Comprehensive software is provided.



£ 595

(All prices are exclusive of VAT and P&P)

Interested? Then write or fax for a FREE demo diskette to

INSTRUTEK (UK)

28 Stephenson Road
Industrial Estate
St Ives, Cambs PE17 4WJ
England

Telephone (0480) 460 028
Fax (0480) 461 654

I²C EEPROM

XICOR's X2404 or Philips' PCF8582 EEPROM with integral I²C interface can be connected to the I²C interface published last year[1] via a 6-way PCB mount mini DIN socket.

The bus address of IC_1 (see **Fig. 1**) may be preset with the aid of jumpers A0, A1 and A2. The complete binary address of the PCF8582 is

1 0 1 0 A2 A1-A0 R/W>.

With the jumpers positioned as shown, the address is $A0_{HEX}$.

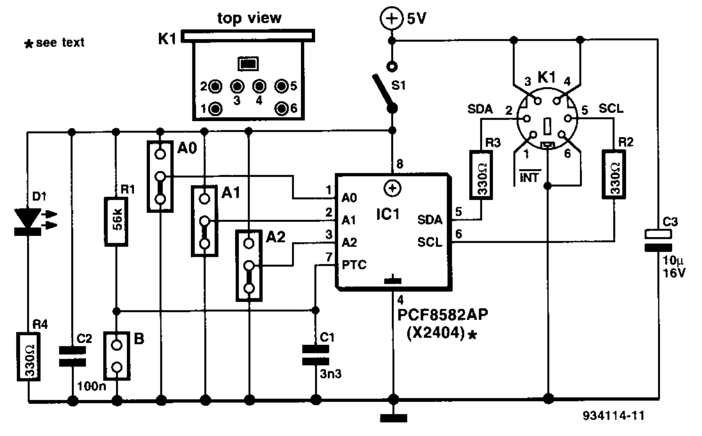
The X2404 is pin compatible with the PCF8582 but has twice its memory: two pages of 256 bytes each. Pages are selected by the software with the aid of the P bit in the I²C address:

1 0 1 0 A2 A1 P R/W>.

When the X2404 is used, jumper A0 must always be connected to earth. With the jumpers positioned as shown, the address for the first page is $A0_{HEX}$ and that for the second page, $A2_{HEX}$.

Before new data can be stored in the EEPROM, the internal oscillator needs to be actuated by connecting network R_1C_1 to the TEST input (not necessary with the X2404, whose pin 7 should be connected to earth: close jumper B). The erase/write time, T_{ew}, is not greater than 10 ms with the X2404, and about 30 ms (R_1C_1) with the PCF8582. The current drawn by IC_1 during erase/write operations may go up to 30 mA (X2404) or 2 mA (PCF8582). In the

1



2

```
unit PCF8582;
(***********)

{ Library to control the PCF8582 I²C EEPROM (256 * 8 bits).}

{ Requirements:
            MS-DOS r 3.3
            I2CDRIV2.SYS added to CONFIG.SYS
            Elektor I}C PC hardware interface
            PCF8582 (compatible) I}C EEPROM
            Special unit: I2C2.TPU

       Source............... PCF8582.PAS
       Executable........... -
       Language............. Turbo Pascal 5.5
       Version.............. 1.0
       Date................. 26-03-1993
       Written by........... P. J. Ruiters.
       Copyright............ Elektor Electronics / Elektuur (c) 1993
       Order information.... ESS182x (diskette 5, inch 360 K: I2CDRIV2 & I2C2)
}

{ Compiler directives.        } {$R-,S-,I-,F-,O-,A-,V+,B-,N-,E+,D-,L-}

INTERFACE
{==================================================================
=======}

{——————————————————————————-}uses
{ Used units.               }  I2C2,crt;
{——————————————————————————-}const
{ Erase/write cycle time of the }  Tew=50;
{ EEPROM (milli seconds).      }
{——————————————————————————-}var
{ I}C definition}  Bus:I2Cfile;
{ I}C address of PCF8582 EEPROM.}  PromAddr:byte;
{——————————————————————————-}

procedure WriteByteProm(PromDataAddr,PromData:byte);

procedure ReadByteProm(PromDataAddr:byte; var PromData:byte);

IMPLEMENTATION
{==================================================================
=======}


{
WriteByteProm-
                    Store PromData into the EEPROM at address PromDataAddr.
}
procedure WriteByteProm(PromDataAddr,PromData:byte);
{——————————————————————————-}begin(* WriteByteProm *)
{ Generate start condition on}  if Start(Bus)<>0
{ I}C bus.}    then
{}     begin
{} writeln('I}C error (start).');
{} halt;
{}     end;
{ Address I}C EEPROM}  if Address(PromAddr)<>0
{}    then
{}     begin
{}       writeln('I}C error (address).');
{}       halt;
{}     end;
{ Write data byte to EEPROM.}  write(Bus,PromDataAddr,PromData);
{ Generate stop condition on    }  close(Bus);
```

3

```
{ I²C bus.                }
{ Wait until erase/write cycle }  delay(Tew);
{ time elapsed.}
{——————————————————————————-}end;  (* WriteByteProm *)


{
ReadByteProm-
                    Read the contents of the EEPROM at address PromDataAddr.
                    The result
                    is returned via PromData.
}
procedure ReadByteProm(PromDataAddr:byte; var PromData:byte);
{——————————————————————————-}begin (* ReadByteProm *)
{ Generate start condition on }  if Start(Bus)<>0
{ I}C bus.}    then
{}     begin
} writeln('I}C error (start).');
{} halt;
{}     end;
{ Address I}C EEPROM.}  if Address(PromAddr)<>0
{}    then
{}     begin
{}       writeln('I}C error (address).');
{}       halt;
{}     end;
{ Set EEPROM location to read.}    write(Bus,PromDataAddr);
{ Read data byte from EEPROM.   }    read(Bus,PromData);
{ Generate stop condition on}    close(Bus);
{ I}C bus.}
{——————————————————————————-}end;  (* ReadByteProm *)

{——————————————————————————-}begin (* PCF8582 *)
{——————————————————————————-}end.  (* PCF8582 *)
```

standby mode and during read operations, the current is appreciable lower. The overall current drain is then almost entirely that through D_1, that is, 10 mA.

The Pascal unit in **Fig. 2** contains procedures for programming and reading the EEPROM. With WriteByteProm data may be stored byte by byte. Via PromDataAddr access may be had to each address; this is also true for the ReadBytePromread procedure. To use the unit, 'PCF8582' or 'X2404' must be added to the USES command in the source code of the application program in use.

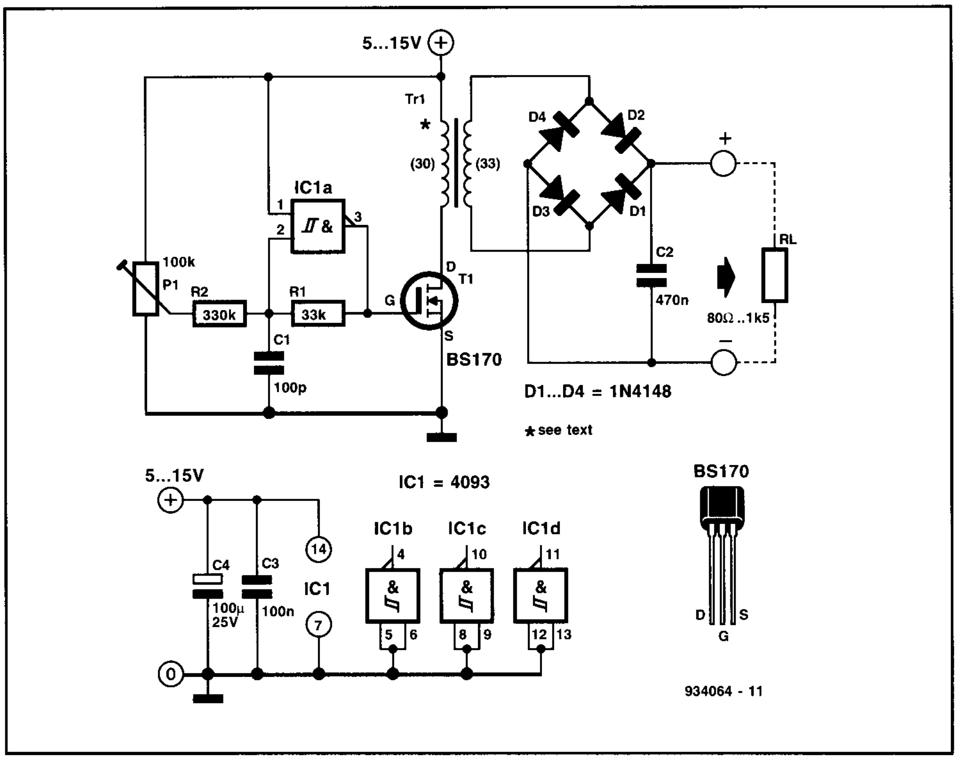
[J. Ruiters - 934114]

NOTE: After this article had been written, it was learned that the PCF8582AP has been superseded by the PCF8582E-2P.

---

[1] *Elektor Electronics*, February 1992, page 36.

SMALL POWER CONVERTER



The converter enables an existing positive supply voltage to be raised, to be lowered, or to be changed into a negative potential.

The new voltage is electrically isolated from the source by a DIY transformer wound on a G2-3FT12 toroid. The primary winding consists of 30 turns. The number of secondary turns is calculated from

$$n = 30U_0 / U_i,$$

where U_0 is the wanted voltage and U_i is the input voltage. Increase the number of turns so found by 10–20 to compensate for losses. If the output voltage is somewhat too large, it can always be reduced with P_1. Both windings must be wound with 0.3 mm dia. enamelled copper wire. Make sure that the turns of both are evenly distributed along the core.

The transformer is driven by a CMOS Schmitt trigger NAND gate that has been converted to a rectangular-wave generator by R_1 and C_1. MOSFET T_1 serves as output stage. Additional charging current for C_1 is provided via R_2 and P_1, which control the duty factor of the rectangular signal. The frequency of this signal is about 220 kHz and its duty factor must be smaller than 0.5.

When T_1 is switched on, some energy is transferred to the secondary winding and some is stored in the magnetic field. When T_1 stops conducting, the energy in the magnetic field is transferred to the secondary winding.

The idea is to make the duty factor small enough to ensure that all energy stored in the field is transferred before T_1 switches on again. If not, there is the risk that the residual magnetic field becomes stronger and stronger, which causes the core to become saturated and this in turn lowers the efficiency. Also, owing to the reduced inductance at the primary side, the current through T_1 will rise appreciably, which means the end of the transistor.

The current through T_1 will also rise dangerously when the secondary load is too heavy. The average current through the primary should not exceed 150 mA (the peak current may be several times larger). From the turns ratio it is easily calculated what the maximum secondary load current should be. With the ratio shown in the drawing (10% extra turns at the secondary side), the secondary load should be not smaller than 80 Ω,

Apart from a heavy load, no load is also to be avoided. In that case, the energy stored in the magnetic field can only move to C_2 where it is stored in the electric field. This means that the charge on C_2, and thus the voltage across it, increases to a level where it can have a serious effect on the circuit to which the converter will be connected. As a rule of thumb (just as with the maximum load current), the indicated value of 1.5 kΩ is directly proportional to the turns ratio.

The Type 1N4148 rectifier diodes are fast enough to cope with the frequency of 220 kHz (1N400x types are not). These diodes can stand a constant current of 200 mA (400 mA peak).

The efficiency of the convertor with a supply voltage of 15 V is about 65%. When the load current is small, this drops to about 50%. The efficiency also drops when the supply voltage is lower than indicated.

The maximum input voltage is 15 V, since the supply to neither IC_1 nor T_1 must exceed this value. The current drawn from a 15 V source and a load of 80 Ω is about 165 mA.

The prototype worked fine with the wiper of P_1 turned completely to **+**; it may even be possible to lower the value of R_2 slightly.

If necessary, the duty factor of the rectangular voltage may be increased somewhat with P_1. When this is being done, the current through T_1 should be watched carefully, preferably on an oscilloscope. If the current suddenly rises too fast, the core is becoming saturated and this means that P_1 must be turned back slightly. Bear in mind that when P_1 is set to a critical position, a slight change in load can drive the core into saturation, with all the consequences of this.

[T. Giesberts - 934064]

SOLID-STATE VOICE RECORDER

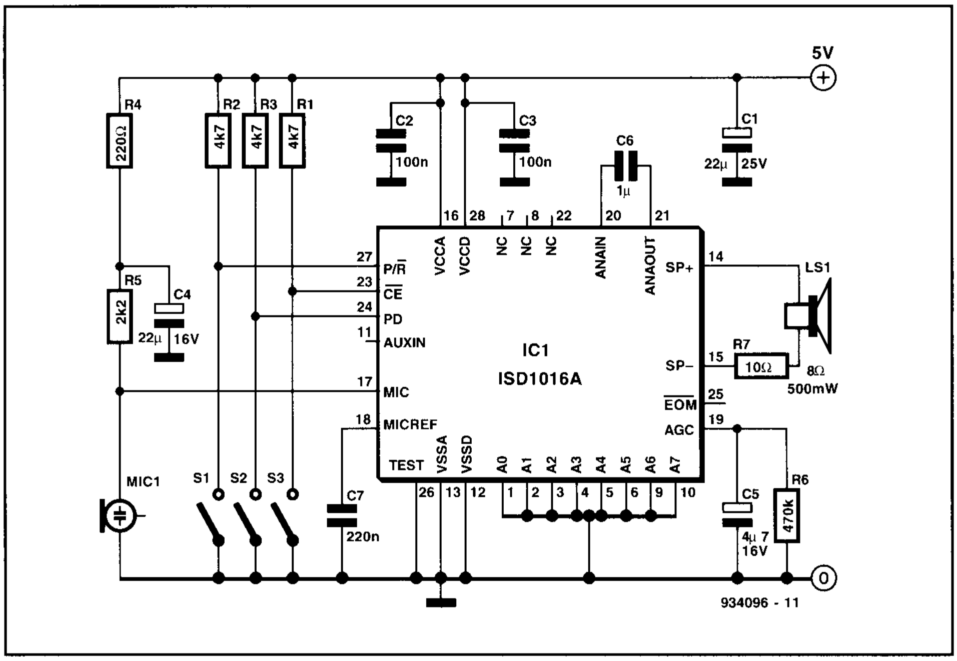
Integrated circuits ISD1012, ISD1016, and ISD1020 from chip maker ISD enable sounds to be recorded and played back. The final two digits in the type coding show the length of a sound message in seconds. The difference in recording and play back time is caused by the sampling frequency, which is highest (10.6 kHz) for the shortest time.

The circuits have a non-volatile memory that can store the recorded sound for not less than ten years without any supply voltage. The circuits also contain a microphone amplifier and an output amplifier.

The drawing shows the simplest circuit for using one of these ICs: an electret microphone, a loudspeaker, three operating switches and a power supply.

Switch S_1 is the recording/playback switch: for recording, it must be closed.

Switch S_2, when open, sets the IC to the power-down mode. The larger part of the circuit is then switched off, which reduces the current drain. Switching to power down also serves as a reset when, for instance, during recording an overflow occurs (message too long). The IC indicates this by making the end-of-message (EOM) output low during the recording.



Recording or playback is started by closing S_3. This switch must remain closed during recording and should preferably be a push-button type.

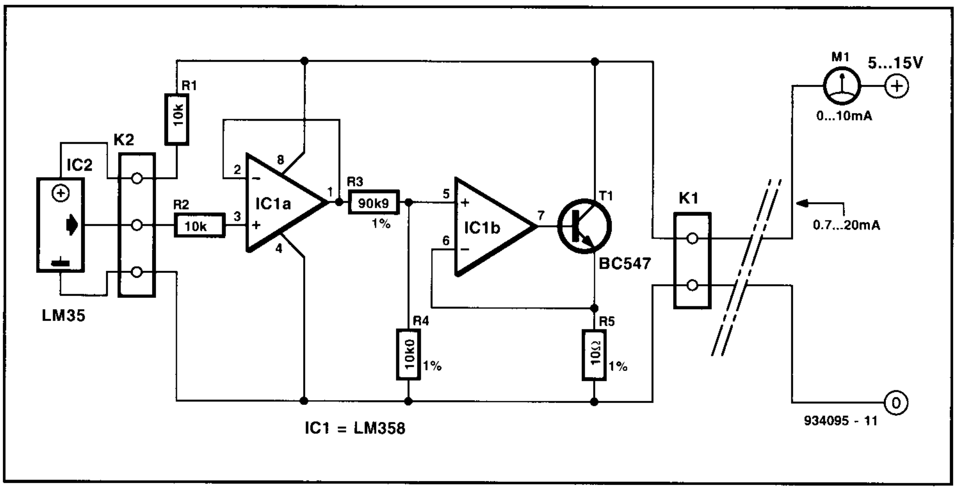
The circuit is kept simple, although it is possible to connect several ICs in cascade if longer messages, or a number of short ones, are to be recorded.

The bandwidth of the circuits is similar to that of telephones: ISD1012 – 4.5 kHz; ISD1016 – 3.4 kHz; ISD1020 – 2.7 kHz. The current drain during playback is about 25 mA.

[L. Lemmens - 934096]

ACTIVE TWO-WIRE TEMPERATURE SENSOR

When a physical quantity (measurand) has to be measured at a distance, it is normally necessary to provide the sensor proper with an amplifier. This amplifier needs a power supply, which means that a third wire has to be taken to the sensor. In the present circuit, the measurand and the power supply use the same two lines. To that end, the measurand, buffered by IC_{1a}, is converted into an additional supply current drawn from current source IC_{1b}. In other words, the magnitude of the input voltage may be gauged from the level of the supply current (which, of course, also consists of the current drawn by the opamp and, possibly, the sensor).



When the specified sensor and opamp are used, the current is about 0.7 mA (0.65 mA with a supply voltage of 5 V; 0.7 mA at 10 V; and 0.77 mA at 15 V). With a ful-scale deflection (FSD) of 10 mA, this is a deviation of about 7%, which is, however, easily compensated.

The circuit design is such that when the temperature at the sensor varies from 0 °C to 100 °C, the supply current changes from 0.7 mA to 10.7 mA. Thus, a moving coil ammeter in the supply line enables the temperature to be read quite simply; the supply current to the opamp (0.7 mA) is nullified with the adjustment screw on the meter.

Note that the voltage drop across long lines must be compensated by a higher supply voltage to prevent that IC_1 and IC_2 are under-powered (they must get at least 5 V).

[L. Pijpers - 934095]

SUMMER 1993 CATALOGUE

The new enlarged Cirkit Catalogue is out now!

- 32 more pages
- New range of Kenwood 'scopes
- The latest scanning receivers and accessories
- New section of low cost security products
- Extended range of Velleman kits including: 250W 12Vdc to 220Vac inverter, in-car amplifier power supply, 200 and 400W amplifiers, suppressed lamp dimmer, halogen lamp dimmer, day/night thermostat and telephone remote control unit
- New test equipment, includes: 2.3GHz bench frequency counter, EPROM emulator/programmer, portable 'scopes and bench function generators
- Host of new components, including: compression trimmers, variable capacitors, connectors, fuses, and fuseholders, potentiometers, IC's, soldering irons and lead free solder
- Published 27th May 1993
- Available from most large newsagents or directly from Cirkit
- **Send for your copy today!**

£1.90 + 30p p&p

Cirkit

CIRKIT DISTRIBUTION LTD
Park Lane · Broxbourne · Hertfordshire · EN10 7NQ
Telephone (0992) 444111 · Fax (0992) 464457

8051 TOOLS

ICL51 £225

Low cost entry level In-Circuit-Emulator for the 8031/51. Operates at 11Mhz 28k bytes of program memory, includes many features to aid program development but uses some resources of the target 8051.

ICE51+ £495

Advanced emulator for the 8031/51. Operation selectable up to 16MHz, 64k bytes of program memory, uses none of the target (8051) resources.

8051 "C" COMPILER £125

Micro/C51 is an integer 'C' like compiler for the MCS51 family. Easily customised for any MCS51 family variant. High level language debugger available (£95)

8051 BOOK £49.95

A very good text on the 8051 architecture, programming and application. The book is supplied with free (un-supported) IBM/PC based assembler and simulator.

Other tools available ***prices exclude VAT and delivery***

Micro AMPS Limited
66 SMITHBROOK KILNS,
CRANLEIGH,
SURREY GU6 8JJ, UK
Tel: +44(0)483 268999
Fax: +44(0)483 268397

OSCILLOSCOPES

HEWLET PACKARD 1740,1741,1744 100MHz DUAL CHANNEL	**£350**
HEWLET PACKARD 1707A, 1707B -75MHz DUAL CHANNEL	**£275**
HEWLET PACKARD 182C 100MHz FOUR CHANNEL	**£350**
TEKTRONIX 453,454,465,465B, 475, 475A,466,468 · 100 to 250MHz DUAL CHANNEL	**from £250**
TEKTRONIX 7603,7613,7623,7633,7313,7704A,7844,7904 · 100 to 500MHz TWO or FOUR CHANNEL	**from £350**
(VARIOUS PLUG-IN OPTIONS AVAILABLE)	
TELEQUIPMENT DM63, D75, D83 50MHz DUAL CHANNEL	**from £175**
GOULD ALSO MODELS OS 245,OS 4000, OS 4020, OS 4200 FROM	**£125**
GOULD 400-20MHz BAND WIDTH · 100MS/S SAMPLING RATE · AS NEW	**£1350**
PHILLIPS 3211, 3212, 3217, 3226, 3240, 3243, 3244, 3261, 3262 · 15 TO 120MHz TWO AND FOUR CHANNEL	**from £125 to £350**
SOLARTRON SCHLUMBERGER CD 1740 20MHz · FOUR CHANNEL	**from £250**
DUMART 1062 50MHz · DUAL CHANNEL	**£250**

SPECTRUM ANALYSERS

HEWLETT PACKARD 3580A · 5Hz to 50KHz	**£1250**
HEWLETT PACKARD 3582A · 25KHz DUAL CHANNEL	**£3000**
HEWLETT PACKARD 3585A · 20Hz to 40KHz (GPIB)	**£4750**
HEWLETT PACKARD 182T MAINFRAME WITH 8559A (10MKHz to 21GHz)	**£3750**
HEWLETT PACKARD 8590A · 10MHz to 1.50GHz PORTABLE	**£5000**
AILTECH 727 20GHz	**£2200**
MARCONI 2370 110MHz	**£1250**
MARCONI 2371 200MHz	**£1750**

MISCELLANEOUS

HEWLETT PACKARD 3701A/3702A/3703A · MICROWAVE LINK ANALYSER	**£1000**
HEWLETT PACKARD 3702B/3705A/3710A/3716A · MICROWAVE LINK ANALYSER	**£1500**
HEWLETT PACKARD 3779A PRIMARY MULTIPLEX ANALYSER	**£1000**
HEWLETT PACKARD 415E S.W.R. METER	**£275**
HEWLETT PACKARD 8750A STORAGE NORMALISER	**£400**
HEWLETT PACKARD 5342A FREQUENCY COUNTER (18 GHz)	**£1400**
HEWLETT PACKARD 8443A TRACKING GENERATOR/COUNTER	**£450**
HEWLETT PACKARD 8445B AUTOMATIC PRE-SELECTOR	**£700**
HEWLETT PACKARD 4953A PROTOCOL ANALYSER	**£2500**
HEWLETT PACKARD 3456A DIGITAL VOLTMETER	**£675**
HEWLETT PACKARD 8011A PULSE GENERATOR	**£500**
HEWLETT PACKARD 8013B PULSE GENERATOR	**£750**
KEITHLY 197AUTO D.M.M. WITH IEEE	**£400**
MARCONI 2830 PCM MULTIPLEX TESTER	**£1250**
MARCONI 2831 CHANNEL ACCESS SWITCH	**£500**
RACAL-DANA 9081 SYNTHESISED SIGNAL GENERATOR (520 MHz)	**£550**
RACAL-DANA 9084 SYNTHESISED SIGNAL GENERATOR	**£500**
RACAL-DANA 9303 TRUE RMS R/F LEVEL METER	**£650**
ANRITSU - ME588C MICROWAVE SYSTEM ANALYSER (AS NEW)	**£3500**
AVO - RM215 L/2 · BREAKDOWN/LEAKAGE + IONISATION TESTER	**£500**
DATRON 1061A · AUTOCAL MULTI FUCTIONAL VOLTMETER (6.5 DIGITS)	**£950**
DATRON 1071 · AUTOCAL MULTI FUCTIONAL VOLTMETER (7.5 DIGITS)	**£1150**
FARNELL RB1030-35 ELECTRONIC LOAD	**£450**
GALLENKAMP 300+ SERIES THERMOSTAT/CYCLIC TIMER/ TEMPERATURE CYCLING OVEN	**£750**
MULTICORE SOLDERABILITY TESTER	**£250**
ROHDE + SCHWARZ QDM BN 36711 DIGITAL 'Q' METER	**£400**
PHILLIPS 5167 1 · 10MHz FUNCTION GENERATOR	**£400**
PHILLIPS PM6672 TIMER COUNTER 1GHz WITH IEEE	**£650**
SOLARTRON/SCHLUMBERGER 1170 FREQUENCY RESPONSE ANALYSER	**£500**
SOLARTRON/SCHLUMBERGER 3530 ORION DATA LOGGING SYSTEM	**£750**
WAYNE KERR B905 · AUTOMATIC PRECISION BRIDGE	**£800**
WAYNE KERR 3245 · PRECISION INDUCTANCE ANALYSER	**£2500**
WAYNE KERR 6425 PRECISION COMPONENTS ANALYSER	**£2500**
WILTRON 352 · LOW FREQUENCY DIFFERENTIAL INPUT PHASE METER	**£350**
WILTRON 560 · SCALAR NETWORK ANALYSER	**£900**
YOKOGAWA YEW 3655 ANALYSING RECORDER	**£850**
B & K · 2511 VIBRATION METER	**£1100**
B & K 2512 VIBRATION METER (2511 +1621)	**£1750**
B & K · 2515 VIBRATION METER (FFT)	**£4500**

MANY MORE ITEMS AVAILABLE - SEND LARGE S.A.E. FOR LIST OF EQUIPMENT
ALL EQUIPMENT LISTED HERE IS USED, WITH 30 DAYS GUARANTEE
Please check availability before ordering. Carridge + VAT to be added to all goods

TELNET

8, Cavans Way, Binley Ind. Estate, Coventry. CV3 2SF
(Premises situated close to Eastern Bypass in Coventry with easy access to M1, M6, M40, M42, M69, M45.)
TELEPHONE 0203 - 650702 FAX 0203 - 650773

STEREO PWM OUTPUT AMPLIFIER

The most remarkable feature of this small stereo amplifier is the use of a stepper motor bridge driver IC as a stereo power output stage. The circuit diagram shows a three-stage pulse-width modulation (PWM) converter/amplifier for each channel. The left (L) and right (R) audio input signals are first converted into triangular waveforms by opamps IC_1 and IC_2, which are wired as integrators, with feedback from the power output stage via resistors R_7 and R_{11}. Next, the triangular waveforms are converted into rectangular signals with a variable pulsewidth by opamps IC_3 and IC_4, which drive the digital inputs of the bridge power amplifier, IC5.

The L6203 from SGS-Thomson is actually a full bridge driver for motor control applications. Its DMOS output transistors have an $R_{D\text{-}S(on)}$ resistance of only 0.3 Ω, which results in low dissipation and, consequently, high efficiency. Each channel (half bridge) of the device is controlled by a separate logic input, while a common 'enable' (pin 11) is available to switch both channels on and off. In the present application, the channels are enabled by a +5.1 V level derived from the IC's voltage reference output. Although the L6203 contains a bridge circuit, the loudspeakers are connected single-ended for a stereo output arrangement.

The test results obtained with a prototype of the amplifier are not spectacular but none the less worth mentioning.

With a supply voltage of 12 V and an input frequency of 1 kHz, a maximum output power of 2 W was supplied into a load of 4 Ω. The nominal input level required for this output power was 2 V_{rms}. A damping factor of 20 was measured, while the distortion was about 1.5%.

These figures change slightly when the supply voltage is increased to 14.4 V. Maximum output power, for instance, increases to about 2.8 W with a distortion of about 1.5%. The input drive level required for this output power is 2.25 V_{rms}. With full drive, the amplifier achieves an efficiency of about 73%, with PWM clock intermodulation products down to –40 dB.

At lower input signal levels, the distortion of the amplifier remains around 0.3%, and the noise level at about –80 dB.

(SGS-Thomson application — 934076)

Parts list

Resistors:
R_1, R_2 = 47 kΩ
R_3, R_4 = 33 kΩ
R_5, R_6 = 2.2 kΩ
R_7, R_{11} = 18 kΩ
R_8, R_{12} = 22 kΩ
R_9, R_{13} = 100 kΩ
R_{10}, R_{14} = 470 Ω
R_{15}, R_{16} = 10 kΩ
R_{17}, R_{18} = 1 kΩ

Capacitors:
C_1 = 10 µF, 25 V
C_2 = 10 µF, 25 V radial
C_3 = 100 µF, 25 V radial
C_4, C_5 = 560 pF, polystyrene
C_6 = 220 µF, 25 V radial
C_7, C_8 = 22 nF
C_9 = 220 nF
C_{10}, C_{11} = 470 nF
C_{12}, C_{13} = 2200 µF, 25 V, radial

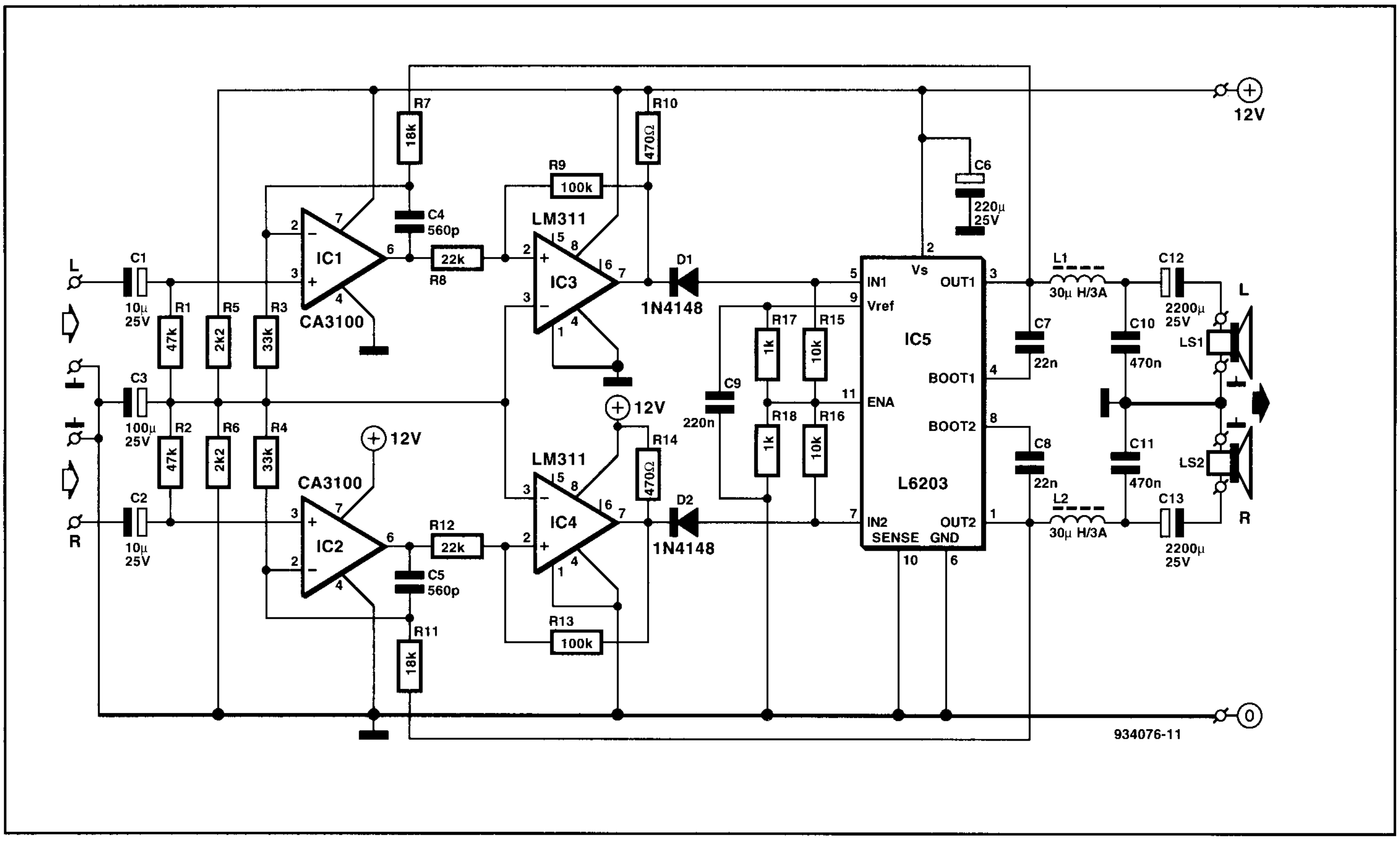
Inductors:
L_1, L_2 = 30 µH/3 A toroid choke

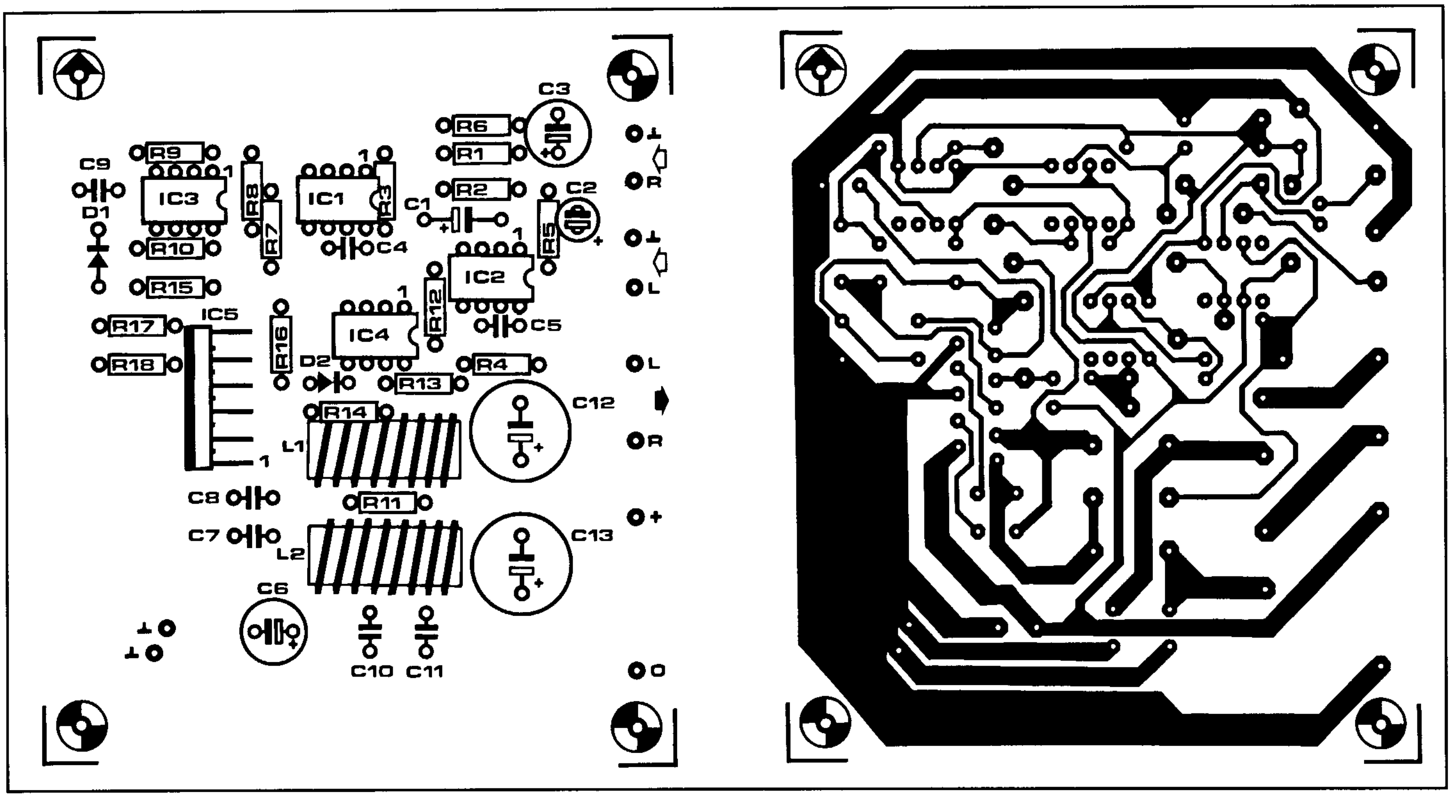
Semiconductors:
D_1, D_2 = 1N4148

Integrated circuits:
IC_1, IC_2 = CA3100*
IC_3, IC_4 = LM311N
IC_5 = L6203**

* Harris Semiconductor UK distributors: Farnell Electronic Components Ltd. (0532) 636311; Thame Components Ltd. (0844) 261188.

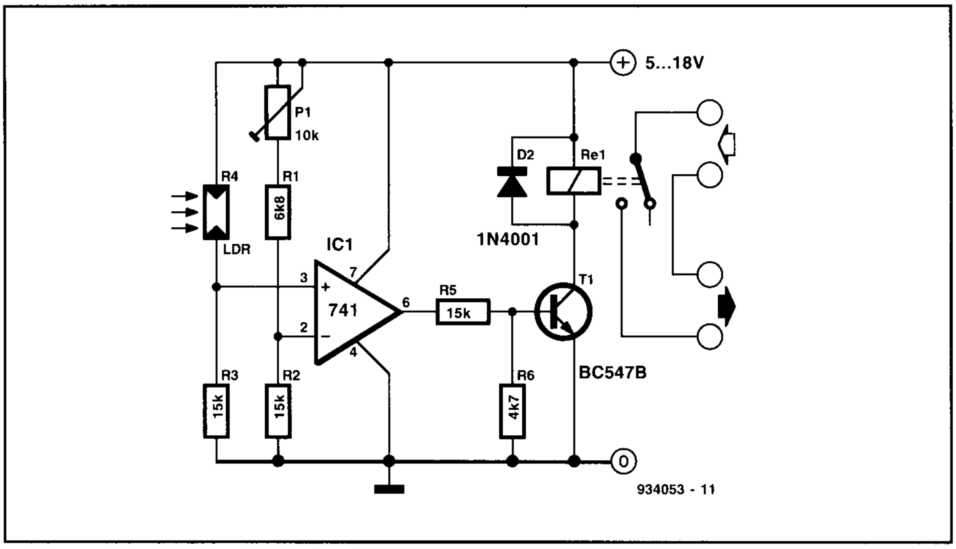
** SGS Thomson Microelectronics UK distributors (among others): Abacus Electronics Ltd. (0635) 33311; Access Electronic Comp. Ltd. (0462) 480888; Farnell Electronic Components Ltd. (0532) 636311.





OPTICAL SQUELCH

Many of the less expensive shortwave receivers have no squelch circuit and continue to emanate noise when no usable signal is coming in. Fortunately, they normally have an LED which lights to indicate that the level of an incoming signal is at or above a predetermined limit. This LED can be used to control a light dependent resistor (LDR). The potential across the LDR can serve to actuate a circuit that switches the loudspeaker or headphones off in the absence of a suitable signal. This is possible without any work in the receiver itself by connecting an external loudspeaker to the headphone output. Inserting the plug into this socket automatically switches off the internal loudspeaker. The connection to the external loudspeaker is via the contact of relay Re_1.



The circuit is based on comparator IC_1. P_1, R_1 and R_2 provide the reference voltage at the inverting input of the opamp, which in the quiescent state (when no light falls on to R_4, which then has a high resistance) is higher than the potential at the non-inverting input. When light falls on to R_4, its resistance decreases, whereupon the level at the non-inverting input of the comparator becomes higher than that at the –ve input. The output of the comparator then changes state and switches on T_1, whereupon the relay is energized. The relay contact then connects the loudspeaker to the headphone output.

During construction it should be borne in mind that the less ambient light falls on to the LDR, the better the squelch will perform.

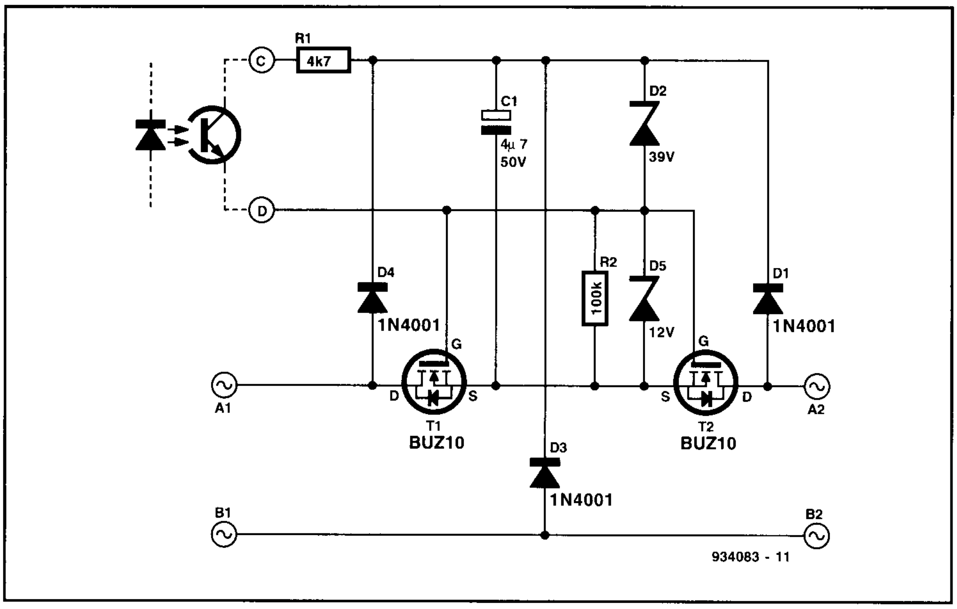
Preset P_1 should be adjusted so that the relay is not energized when the LED is out, but is actuated as soon as the diode lights. If difficulties arise in the setting of P_1, they are probably caused by the LDR having an incorrect value. In the diagram, the values of R_1, R_2 and P_1 are suitable for use with an LDR that has a resistance when light falls on to it of about 6 kΩ. Measure this resistance with a multimeter; the value of R_1 should be made (about) equal to this, and that of P_1 about twice as high. The value of R_2 and R_3 should be roughly the sum of the values of P_1 and R_1.

The power supply may be taken from the receiver; if that is not possible, a separate mains adaptor should be used. The circuit draws a current of about 5 mA plus the relay current.

[K. Walraven - 934053]

LOW-DROP A.C. SWITCH

FOR 12 V HALOGEN LIGHTS



Because of their inertia, power consumption, contact wear, and often size, relays are not really suitable for switching alternating voltages. Moreover, they cannot be used in phase control circuits. Replacing them by triacs may give problems owing to the forward voltage drop across these devices.

A much better solution is the use of anti-series-connected SIPMOS transistors. Unfortunately, these need a control voltage that is isolated from the alternating voltage to be switched. This difficulty is, however, overcome by making use of the inverse diodes of the transistors as shown in the diagram.

In the off condition, when the optoisolator does not conduct, C_1 is charged during the negative half period (A positive, B negative) via D_3 and one of the inverse SIPMOS diodes. If the output is terminated, the capacitor will also be charged during the positive half period either via D_4 and the inverse diode of T_2 (load between A2 and B2), or via D_4 and the inverse diode of T_1 (load between A1 and B1).

The circuit is switched on by making the optoisolator conduct, whereupon the voltage across C_1 is connected to the gates of T_1 and T_2 via R_1 and the transistor in the optoisolator. Diode D_5 prevents the gate voltage becoming too high. When the circuit is on, C_1 continues to be charged during the negative half periods via D_3 and one of the SIPMOS transistors.

Diode D_2, in conjunction with D_1 and D_4, suppresses current peaks caused by the switching of inductive loads.

The circuit can switch alternating voltages of up to 45 V. Without a heat sink for the SIPMOS transistors, the maximum current should not exceed 3 A. For larger currents or when large inductive loads are switched regularly, a small heat sink should be used.

[B.C. Zschocke - 934083]

Please mention **ELEKTOR ELECTRONICS** *when contacting advertisers*

DATA COMMUNICATIONS
EQUIPMENT
(SECOND USER)

GDC 2422 V22 bis 2400 2 wire dial or leased line modem.	65.00
IAL/NEC 96/15 Fast Poll leased line modem	95.00
Racal Milgo 9601 V29 leased line modem with Mux option	85.00
Racal Milgo MPS14.4 leased line modem with Mux option	125.00
Racal Milgo Omnimode 96 single Port leased line modem	75.00
Racal Milgo Omnimode 96 modem with 4 Ch Mux option	85.00
Racal Milgo Sync line drivers SLD1 (Table Top)	45.00
Racal Milgo Sync line drivers SLD1 (Rack Mount)	35.00
Racal Milgo Comlink IV Rack mount module	35.00
Infotron Miniature Async line drivers Type LD/8 19.2K (New)	25.00
Gandalf LDS 309A Limited Distance modem Table top version	30.00
Gandalf 3309A Limited Distance Modem Rack Mount module	27.00
Spectron Patch Chassis DPU-V24 (16 Channels)	299.00
Spectron Patch Chassis UDPU-2400 (16 Channels)	398.00

ALL PRICES EXCLUDE VAT. ADD £7.50 PER ITEM FOR CARRIAGE. (UK ONLY) EXPORT TERMS BY ARRANGEMENT. EVERY ITEM IS FULLY TESTED PRIOR TO DESPATCH AND CARRIES A 90 DAY WARRANTY. INSPECTION OF ANY ITEM PRIOR TO ORDER POSSIBLE BY ARRANGEMENT. MANY OTHER DATA COMS ITEMS AVAILABLE. SEND SAE FOR FULL LISTINGS OF SURPLUS EQUIPMENT.

DUBERY ASSOCIATES

UNIT 1, CHALKCROFT, GREEN STREET GREEN ROAD,
DARTFORD DA2 8DX FAX 0474 707641 TEL 0474 708111

IF
AN ADVERT
IS WRONG,
WHO PUTS
IT RIGHT?

We do.

The Advertising Standards Authority ensures advertisements meet with the strict Code of Advertising Practice.

So if you question an advertiser, they have to answer to us.

To find out more about the ASA, please write to
Advertising Standards Authority,
Dept X, Brook House,
Torrington Place,
London WC1E 7HN.

ASA

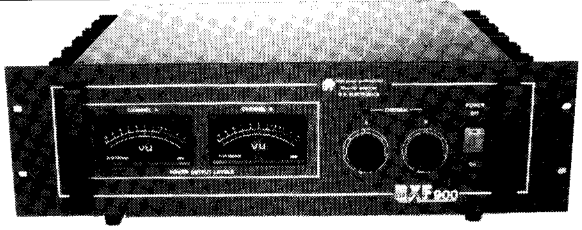
This space is donated in the interests of high standards in advertisements.

POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE (A4) S.A.E., 60p STAMPED FOR CATALOGUE ★

OMP MOS-FET POWER AMPLIFIERS
HIGH POWER, TWO CHANNEL 19 INCH RACK

THOUSANDS PURCHASED BY PROFESSIONAL USERS



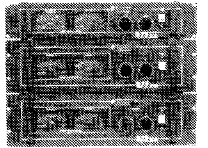
THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- **MXF200** (100W + 100W) **MXF400** (200W + 200W) **MXF600** (300W + 300W) **MXF900** (450W + 450W)

ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

FEATURES: ★Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

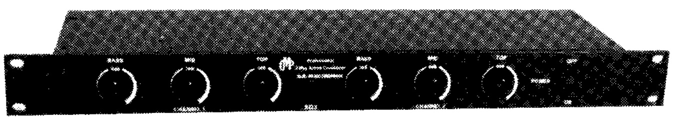
USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.



SIZES:- MXF200 **W19″xH3½″ (2U)xD11″**
MXF400 **W19″xH5¼″ (3U)xD12″**
MXF600 **W19″xH5¼″ (3U)xD13″**
MXF900 **W19″xH5¼″ (3U)xD14¾″**

PRICES:- MXF200 £175.00 MXF400 £233.85
MXF600 £329.00 MXF900 £449.15
SPECIALIST CARRIER DEL. £12.50 EACH

OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER

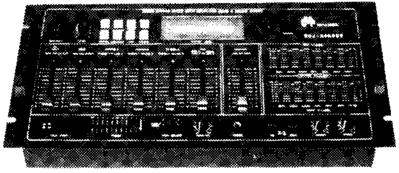


Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

Price £117.44 + £5.00 P&P

STEREO DISCO MIXER SDJ3400SE ★ ECHO & SOUND EFFECTS★

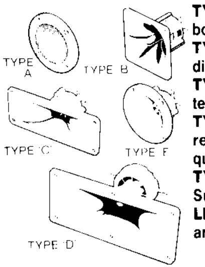
STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.**



Price £144.99 + £5.00 P&P **SIZE: 482 x 240 x 120mm**

PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover **is not** required these units can be added to existing speaker systems of up to 100 watts (more if two are put in series. **FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN1036A) 3″ round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi apeakers. **Price £4.90 + 50p P&P.**
TYPE 'B' (KSN1005A) 3½″ super horn for general purpose speakers, disco and P.A. systems etc. **Price £5.99 + 50p P&P.**
TYPE 'C' (KSN1016A) 2″x5″ wide dispersion horn for quality Hi-Fi systems and quality discos etc. **Price £6.99 + 50p P&P.**
TYPE 'D' (KSN1025A) 2″x6″ wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. **Price £9.99 + 50p P&P.**
TYPE 'E' (KSN1038A) 3¾″ horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. **Price £5.99 + 50p P&P.**
LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. **Price £4.10 + 50p P&P.**

ibl FLIGHT CASED LOUDSPEAKERS

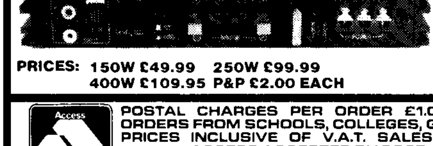
A new range of quality loudspeakers, designed to take advantage of the latest speaker technology and enclosure designs. Both models utilize studio quality 12″ cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complimented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands.

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET
FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

***ibl* FC 12-100WATTS (100dB) PRICE £159.00 PER PAIR**
***ibl* FC 12-200WATTS (100dB) PRICE £175.00 PER PAIR**
SPECIALIST CARRIER DEL. £12.50 PER PAIR

OPTIONAL STANDS PRICE PER PAIR £49.00
Delivery £6.00 per pair

IN-CAR STEREO BOOSTER AMPS



PRICES: 150W £49.99 250W £99.99
400W £109.95 P&P £2.00 EACH

THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS

150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono

ALL POWERS INTO 4 OHMS

Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

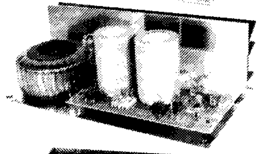
OMP MOS-FET POWER AMPLIFIER MODULES

SUPPLIED READY BUILT AND TESTED.

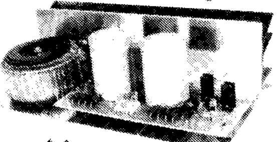
These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

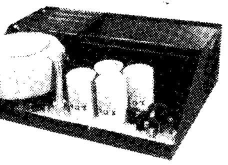


OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P



OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

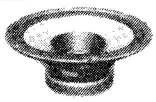
OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P



OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

LOUDSPEAKERS



LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

EMINENCE:- INSTRUMENTS, P.A., DISCO, ETC

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

8″ 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. **PRICE £32.71 + £2.00 P&P**

10″ 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. **PRICE £33.74 + £2.50 P&P**

10″ 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. **PRICE £43.47 + £2.50 P&P**

12″ 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. **PRICE £35.64 + £3.50 P&P**

12″ 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. **PRICE £36.67 + £3.50 P&P**

12″ 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. **PRICE £46.71 + £3.50 P&P**

12″ 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. **PRICE £70.19 + £3.50 P&P**

15″ 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. **PRICE £50.72 + £4.00 P&P**

15″ 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. **PRICE £73.34 + £4.00 P&P**

EARBENDERS:- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ **4 & 8 ohm**)

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

8″ 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. **PRICE £8.90 + £2.00 P&P**

10″ 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. **PRICE £13.65 + £2.50 P&P**

10″ 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. **PRICE £30.39 + £3.50 P&P**

12″ 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. **PRICE £42.12 + £3.50 P&P**

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼″ 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. **PRICE £9.99 + £1.50 P&P**

6½″ 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. **PRICE £10.99 + 1.50 P&P**

8″ 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. **PRICE £12.99 + £1.50 P&P**

10″ 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. **PRICE £16.49 + £2.00 P&P**

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz. VARICAP CONTROLLED PROFESSIONAL PERFORMANCE. RANGE UP TO 3 MILES. SIZE 38 x 123mm. SUPPLY 12V @ 0.5AMP.
PRICE £14.85 + £1.00 P&P

FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC. RANGE 100-300m, SIZE 56 x 46mm. SUPPLY 9V BATTERY.
PRICE £8.80 + £1.00 P&P

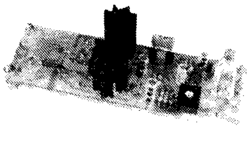


PHOTO: 3W FM TRANSMITTER

POSTAL CHARGES PER ORDER £1.00 MINIMUM. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX.

B.K. ELECTRONICS

UNITS 1 & 5 COMET WAY, SOUTHEND-ON-SEA,
ESSEX. SS2 6TR.
Tel.: 0702 - 527572 Fax.: 0702 - 420243

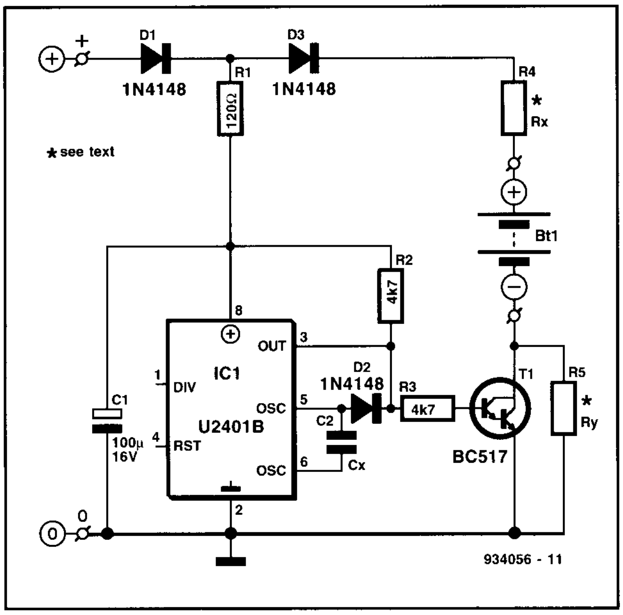
BUTTON-CELL CHARGER

In miniature circuits, the trend is away from expensive dry button cells and to NiCd button types. These batteries are easy to maintain: they may be charged with a constant current for a certain, fixed period, normally 14–16 hours.

The usual NiCd battery chargers are generally not suitable for charging button cells, as their minimum charging current is too high for these cells. The charger described here operates from a 9-V mains adaptor and can charge from one to five button cells.

D_1 is a protection diode, while R_1 and C_1 decouple the supply line to charging processor IC_1, an economy model of the well-known U2400B. D_3 is a safeguard against polarity reversal of the button cells. R_4 limits the charging current to 5 mA. During trickle charging, a current of 0.5 mA flows through R_4 and R_5. The value of C_2 determines the charging time. After the mains adaptor is plugged in, the cells are charged at full current for a period shown in the table (T_1 is on); after that period, trickle charging takes place (T_1 off). The trickle charging current is always $^1/_{10}$ of the full charging current.

[J. Heine - 934056]



C_2 (nF)	Charging time
15	0:58
18	1:10
22	1:26
27	1:46
33	2:09
39	2:33
47	3:04
56	3:40
68	4:27
82	5:22
100	6:33
120	7:51
150	9:49
180	11:47
220	14:25
270	17:41

Table 1

Capacity (mAh)	Charging Current (mA)	R_4 (kΩ) for number of cells 1	2	3	4
8	0.5	15	12	8.2	4.7
15	1.0	6.8	5.6	3.9	2.7
18	1.5	4.7	3.9	2.7	1.8
36	2.0	3.6	2.7	2.2	1.2
75	2.5	2.7	2.2	1.8	1.0
120	5.0	1.5	1.2	0.82	0.47
190	10	0.68	0.56	0.39	0.27
230	15	0.47	0.39	0.27	0.18
310	25	0.36	0.27	0.22	0.12

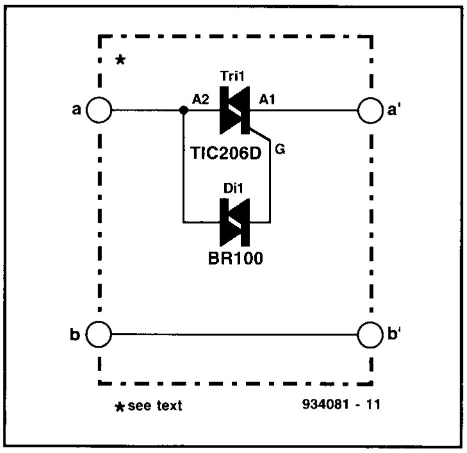
$R_5 = 0.1R_4$

Table 2

PRIVACY PHONE

Undesired listening-in to telephone conversations may be prevented by the present circuit, which requires only two components to protect a telephone.

In each telephone to be protected, a triac is inserted in series with the *a* line. A diac is connected between the anode and the gate of the triac. The trip voltage of the diac is about 25 V, which is appreciably lower than the line voltage of about 50 V, and considerably higher than the potential across a telephone set that is in use (5–12 V). Thus, the triac is switched only if the receivers of all the parallel telephones are on the hook. As soon as a receiver is lifted, the voltage across all sets drops from about 50 V to at most 12 V, so that no diac can be tripped. If, after the receiver has been lifted, the polarity of the line voltage reverse, the diac is not affected. When a call signal is received, all triacs conduct, so that the bell on each telephone will ring.



An added advantage of the present circuit is that it suppresses the parallel tinkling of telephones when a number is dialled on one of them (this happens only where older telephone exchanges are still in use).

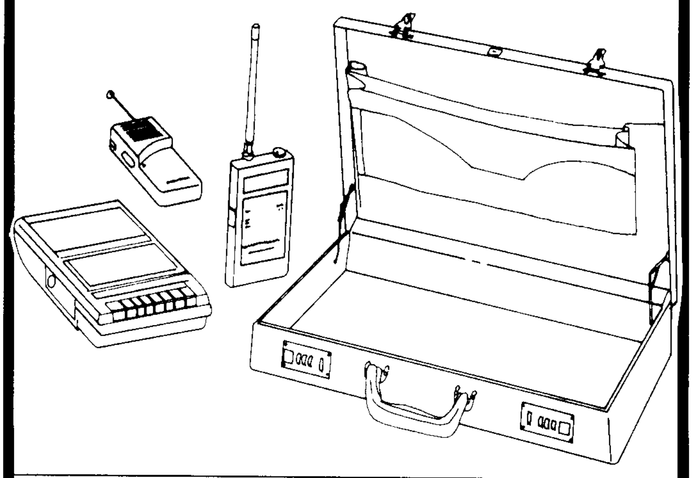
The circuit is small enough to be built into the telephone line outlet box.

[L. Lemmens - 934081]

SURVEILLANCE

SURVEILLANCE

A SMALL SAMPLE OF OUR RANGE	KIT	MODULE	PROF. FINISHED
ROOM TRANSMITTER RT1 An extremely sensitive miniature transmitter with long battery life. Dimensions: 20 x 20mm	9.95	13.75	19.00
MAINS TRANSMITTER MT4 Can be connected inside any equipment that is mains powered. Dimensions 35 x 20mm	19.75	31.50	45.00
TELEPHONE TRANSMITTER TTS Small enough to conceal within a telephone. Will transmit both sides of a conversation (series connection) Dimensions: 10 x 20mm	12.75	17.50	25.00
TELEPHONE SOCKET TRANSMITTER TSTS Replace your telephone socket with this one within which a transmitter has been concealed.	14.74	----	29.00
ROOM AND TELEPHONE TRANSMITTER RTT Operates as a room transmitter, then switches to telephone transmitter mode during telephone calls. Dimensions: 30 x 25mm	31.50	45.50	65.00
AUTOMATIC TELEPHONE RECORDER SWITCH TRS2 Record telephone conversations with this interface unit and your own tape recorder. Dimensions: 36 x 50mm	16.80	25.90	39.00
AUTOMATIC TELEPHONE RECORDER ATR1 Adapt the tape recorder included to record telephone calls automatically.	34.95	-----	59.00
TELEPHONE TAP ALERT TTA1 Visual warning of any invasions of privacy on your telephone line. Dimensions: 38 x 52mm	21.95	31.50	45.00
RF DETECTOR RFD1 Highly sensitive hand-held detector. Range between 10Mhz and 600Mhz. Silent operation. Dimensions: 70 x 50mm	42.75	69.00	95.00
CAMERA DETECTOR CD8 Detects hidden video cameras (even miniature CCD models). Dimensions: 63 x 38mm	69.00	89.00	125.00
RECORDING BRIEFCASE RBC1 Completely discreet recordings at a value for money price.	-----	-----	145.00
SHOTGUN MICROPHONE AMPLIFIER SMA Ideal for surveillance. The amplifier will pick up sounds from a long distance.	24.95	36.00	45.00
SIGNALLING TRANSMITTER SIGT Sends a continual audio pulse. Can be integrated into alarm, tracking or warning systems. Dimensions: 20 x 50mm	21.95	34.89	45.00
TELEPHONE AMPLIFIER TA5 Connected directly to the telephone, this unit will amplify both sides of a telephone call. Dimensions: 25 x 52mm	10.95	16.95	19.95
PROFESSIONAL SOUND TO LIGHT UNIT SK72 Custom built for disco or home use. Audio signal divided into bass, mid and treble bands, with internal microphone and spotlight option. Dimensions 210 x 45mm	21.95	32.49	44.95
MICRO METAL DETECTOR MMD Detect the presence of ferrous and various non-ferrous metals. Useful for all those DIY jobs. Dimensions: 40 x 25mm	9.95	16.95	-----



Please add £2.00 P & P to all orders and 17.5% VAT on all U.K. orders.

For full catalogue please send two 1st class stamps or 2 IRC'S

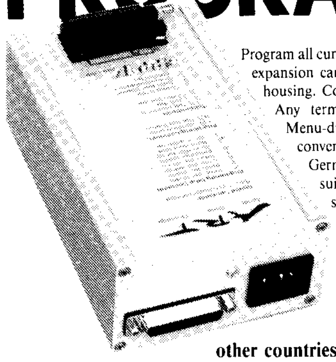
172 Caledonian Road
Dept EL
London N1 0SG

CANAL BRIDGE AUDIO
071-837 4423

VISA

E(E)PROM PROGRAMMERS

MADE IN HOLLAND



Program all current E(E)PROMs. Built-in power supply. No extra expansion card needed. Strong compact anodized aluminium housing. Connectable to any computer with an RS232 port. Any terminal emulator through ASCII command set. Menu-driven software for IBM-compatible, FFC format converter and updatable database. Manual: English, German, French (EPP_2 also Spanish). The EPP_2 is suitable for 8 Mbit devices although detailed specifications of such devices are not yet available.

ART

DEALERS WANTED

UK customers contact Maplin

other countries please contact European HQ Comdis

specifications	EPP_1F	EPP_2
Memory size	1 Mbit	4 Mbit (8 Mbit)
Baudrate	300 up to 19.200	300 up to 19.200
Parity	None, Odd, Even	None, Odd, Even
Handshake	None, RTS/CTS, XON/XOFF	None, RTS/CTS, XON/XOFF
Data format	Motorola s1f, s2f and s3f	Motorola s1f, s2f and s3f
Socket	ZIF-28	ZIF-32
Power	4.5 VA	8 VA
Weight	0.630 kg	0.780 kg
Voltage	115 or 230 VAC	115 or 230 VAC
Dimensions	175 x 103 x 65 mm	175 × 103 × 65 mm

PRICES:

EPP_1F: UK £123,00

EPP_2 : UK £179,00

Why build one yourself if you can buy 'ready-made' at these prices?

Prices do not include taxes. Delivery exworks.

* Payment in advance on our Bank ABN/AMRO, Eindhoven, The Netherlands, Accountnumber: 52.77.86.284. Swift Address: ABNANL 2A ABN/AMRO Amsterdam.

* VISA Card, please add 6%.

All payments must be accompanied by full name and address of customer, quantity and type of programmer. Delivery within 2 weeks upon receipt of payment.

Comdis Nederland P.O. box 4945
5604 CC Eindhoven The Netherlands
Tel.: +31 (0)40-12 82 17 Fax: +31 (0)40-12 82 71

VISA

Computer Distribution, Services & Consultancy

Build your own P.C.

Motherboards

386SX-40MHZ	£65
386DX-40MHZ 128K CACHE	£99
486SX-25MHZ 256K CACHE	£149
486SX-33MHZ 256K CACHE	£169
486DX-33MHZ 256K CACHE	£279
486DX-40MHZ 256K CACHE	£299
486DX2-50MHZ 256K CACHE	£333
486DX-50MHZ 256K CACHE	£369
486DX2-66MHZ 256K CACHE	£389
VESA VL-Bus motherboards add	£20
EISA motherboards please ring	

Add-on Cards

I/O Card 2S/1P/1G	£12
IDE Card 2HD/2FD with Cables	£12
IDE I/O Card 2HD/2FD/2S/1P/1G w cables	£16
IDE Caching Card (0k) 4HD/2FD	£135
16-bit Ethernet Card(NE2000) comp	£55
32-bit Ethernet Card EISA	£159

Display Cards

Mono Card with Printer Port	£13
Oak 16-bit VGA with 256k	£22
Oak 16-bit VGA with 512k	£28
Oak 16-bit VGA with 1MB	£38
Trident 8900cl 16 bit VGA with 1MB	£39

Floppy Disk Drives

5¼" 1.2MB Floppy Disk Drive	£35
3½" 1.44MB Floppy Disk Drive	£33
3½" 1.44MB Floppy with 5¼" Frame	£36

Hard Disk Drives

42MB IDE 14ms	£77
85MB IDE 17ms	£128
130MB IDE 16ms	£145
213MB IDE 14ms	£195
330MB IDE 12ms	£295
420MB IDE 12ms	£360
520MB IDE 12ms	£560
1GB SCSI 9ms	£750

Tape streamers

Jumbo 120MB Tape Streamer	£105
Jumbo 250MB Tape Streamer	£155

Monitors

14" SVGA Colour Monitor (0.28mm)	£175
14" Non-Interlaced Colour Monitor	£199
14" Mono VGA Monitor	£89

Cases

Deluxe Desktop Case	£55
Mini-Tower Case	£59
Tower Case	£89

Other Items

102-Key Keyboard	£22
Mouse (with Software)	£12
1MBx9 SIMM 70ns	£47
4MBx9 SIMM 70ns	£145

Please ring for a copy of our **FREE** catalogue TODAY.
prices exclude VAT & carr. Access & Visa cards welcome.

J. P. Distribution

The Old School, Prickwillow,
Ely, Cambs, CB7 4UN.
Tel / Fax (0353 88325)

INFRA-RED CONTROLLED REMOTE SWITCH

Nowadays, several manufacturers produce ICs that combine an infra-red receive LED with associate amplifier and demodulator. The Type SFH5505A from Siemens, used in the present circuit, has in addition a band-pass filter to minimize any interference. It is best used in conjunction with the infra-red transmitter in the next article.

The output of IC_1 is limited to a maximum pulse width. This is used to advantage by the associated transmitter to span as long a distance as possible. Most commercial remote controls use modulated data transfer, in which the pulse width is smaller than IC_1 can handle. The difference is easily detected by an integrator, R_2-C_2, and a Schmitt trigger, formed by the –T input of monostable IC_{2a}. The time constant is just short enough to ensure that at the maximum pulse width of IC_1 the voltage across C_2 is just under the trigger threshold of IC_{2a} (IC_1 has an active low output, which is why it is connected to the negative trigger input of IC_{2a}). Note that remote control units of, for instance, Sony or Philips, have no effect on the present circuit.

The monostable is retriggerable, so that any bounce at the transmitter does not affect the wanted state of the circuit. The mono time has been set at about half a second. The circuit cannot, therefore, switch on and off rapidly. If nevertheless several or repeated pulses arrive at the trigger input, they cause a lengthening of the output pulse, but the state of the circuit gets changed only once.

The output at pin 7 of IC_{2a} clocks D-type bistable IC_{3a} at the last transition (trailing edge). The bistable is arranged as a binary scaler, so that the circuit can be switched on and off by repeated transmissions.

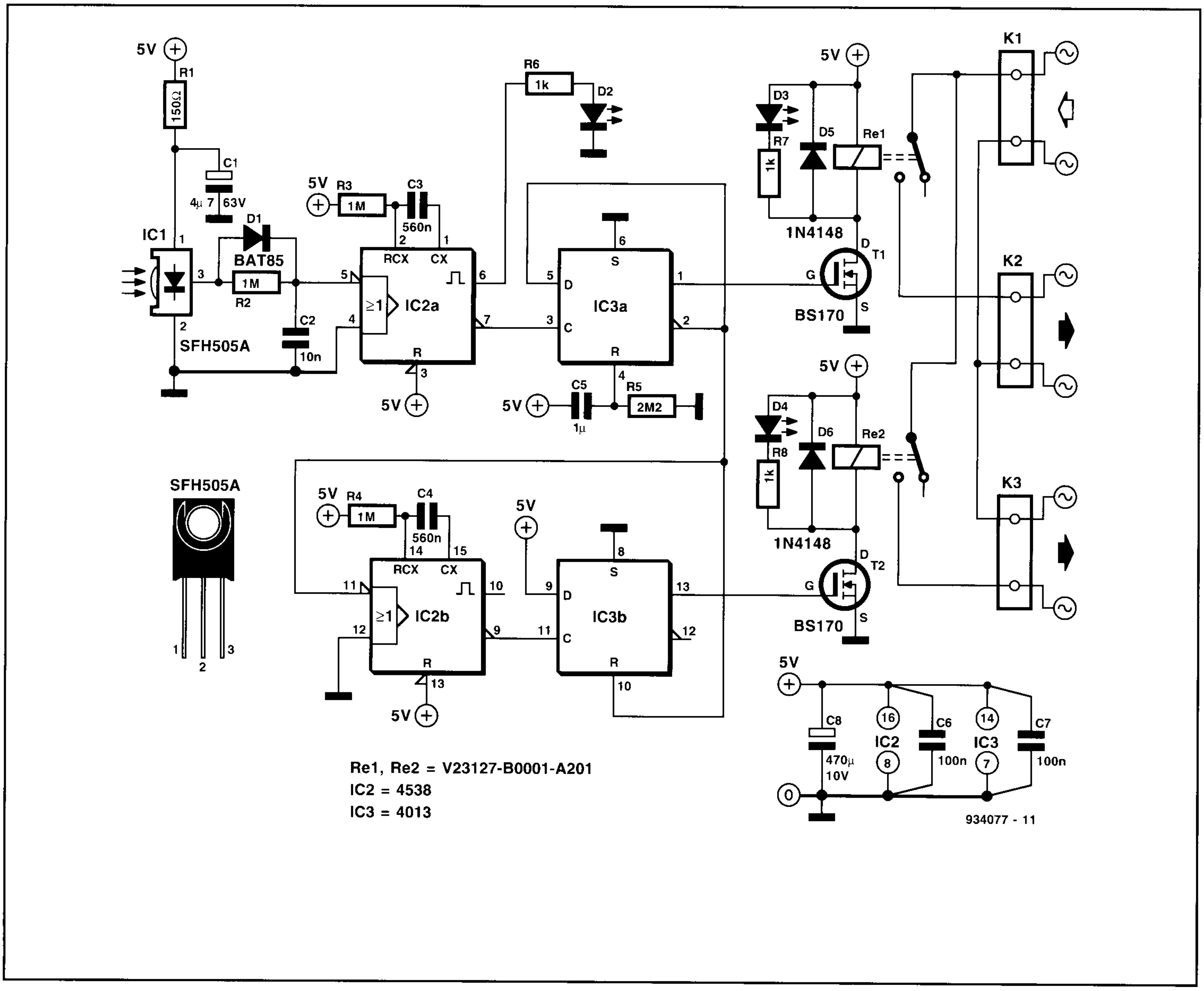
Diode D_2 indicates that IC_{2a} has received a trigger pulse. If interference is experienced from other remote controls, this is indicated by D_2.

The output of IC_{3a} energizes one of the relays via T_1. At the same time, it triggers monostable IC_{2b}, which energizes the second relay via IC_{3b} and T_2. In this way, the second relay is energized a good half a second after the first. This enables several apparatuses to be switched on in two steps. Diodes D_3 and D_4 indicate when the relays are actuated. The relays can switch up to 2000 VA (8 A).

The switch-on current of an equipment may be limited by first switching on the mains voltage with one relay via a series resistor and use the second relay to short out the series resistor.

The circuit draws a current of about 0.6 mA when the relays are unenergized and the LEDs are out. When the relays are actuated and the LEDs light, this increases to 125 mA.

[T. Giesberts - 934077]



Re1, Re2 = V23127-B0001-A201
IC2 = 4538
IC3 = 4013

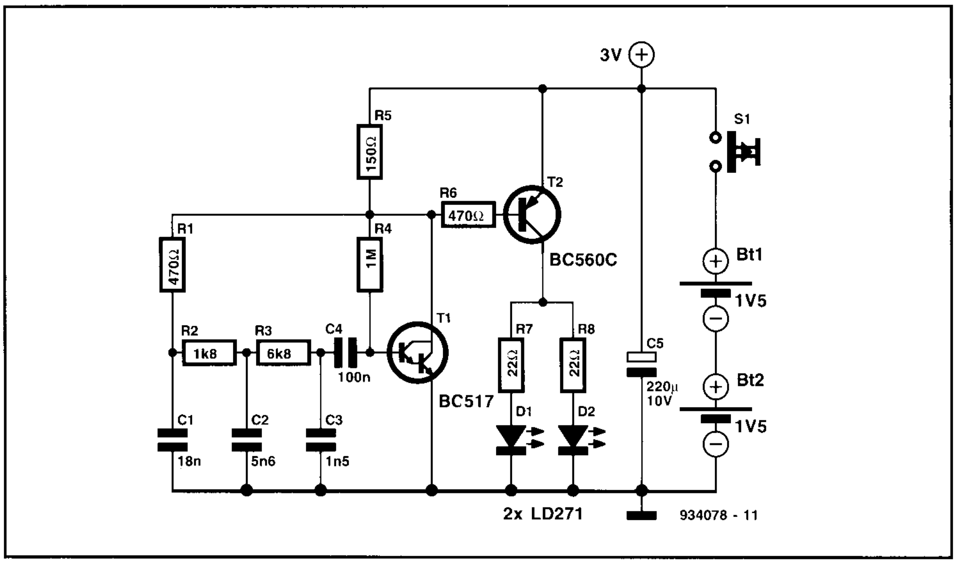
BASIC INFRA-RED TRANSMITTER

The transmitter is intended primarily for use with the receiver in the preceding article. It works from two small 1.5 V dry batteries or one 3 V lithium battery. To make the unit compact and yet have reasonable frequency stability, the design uses a phase-shift oscillator, T_1, which provides good frequency stability. To ensure that the transistor has sufficient amplification at the low supply voltage, it is a darlington.

Each of the branches of phase-shift network, R_1-C_1-R_2-C_2-R_3-C_3 has roughly the same time constant. To ensure that the branches do not affect each other unduly, $R_2 \approx 3.8R_1$, and $R_3 \approx 3.8R_2$. Because of this mutual influence, the gain of the amplifier is somewhat higher than the theoretical value of 18 dB.

The value of R_5 is a compromise. It needs to be low so as not to affect the phase-shift network (the output impedance of T_1 also affects the oscillator frequency). At the same time, it must not be too low, because that would increase the current and reduce the gain.

To lessen the influence of the base-emitter resistance of buffer T_2, this transistor is driven by T_1 via an independent resistor, R_6. The buffer is necessary to provide sufficient current for the LEDs. Owing to the low supply voltage, these diodes cannot be connected in series, and they are, therefore, driven independently via their own series resistor, R_7 and R_8.



The transmitter is switched on and off by connecting or disconnecting the supply voltage with S_1. A drawback of this is that current continues to flow as long as S_1 is pressed. Briefly pressing of S_1 is, however, sufficient to switch the receiver on or off.

The current drawn by the circuit depends on the supply voltage and on how long S_1 is pressed. When $U_b = 2$ V, the frequency is 29.3 kHz, the peak current through each of the LEDs is 25 mA, and the total current drain is 27 mA. When $U_b = 3.2$ V, the frequency is 30.4 kHz, the peak current through each of the LEDs is 64 mA, and the total current drain is 63 mA.. At this supply voltage, the range between the prototype transmitter and receiver was 13 m (43 ft).

The current drain may be reduced by connecting in series with S_1 a parallel *RC* network (R = 10 kΩ; C = 1000 µF, 6.3 V). When S_1 is then pressed, only a brief current pulse ensues; even if S_1 is held down, the current does not rise above about 300 µA.

[T. Giesberts - 934078]

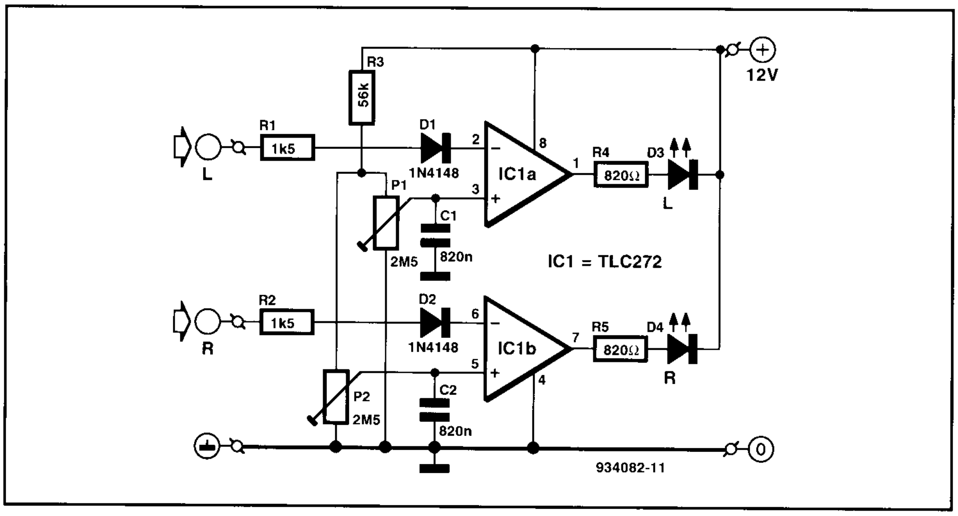
PEAK LEVEL INDICATOR

The indicator shows by means of two LEDs when the signal level in either channel of a stereo audio system exceeds a preset value.

In the diagram, IC_{1a} and IC_{1b} function as comparators. A reference voltage of 0–11 V is applied to their non-inverting inputs by P_1 and P_2 respectively. Resistor R_3 ensures that the reference voltage cannot exceed the common mode range of the opamps.

The signals from the two channels are rectified (half-wave) by D_1 and D_2 and the resulting direct voltage is applied to the inverting inputs of the opamps. Since the input impedance is high, the drop across the diodes is only 200–300 mV. Resistors R_1 and R_2 serve to limit the input current if the drive levels exceed the common mode range.

When the peak value of the input signal rises above the reference voltage less the drop across the diode, the output of the relevant opamp changes state (goes low), whereupon the associated LED lights.



The circuit may be used at frequencies up to 20 kHz (allowing for variations in peak levels of ±0.25 dB).

The indicator draws a current of only 0.25 mA when the LEDs are out and of 24 mA when both LEDs light. This drain may be reduced by the use of high-efficiency LEDs (which draw only 2–3 mA). The value of R_4 and R_5 should then be increased to 3.3 kΩ.

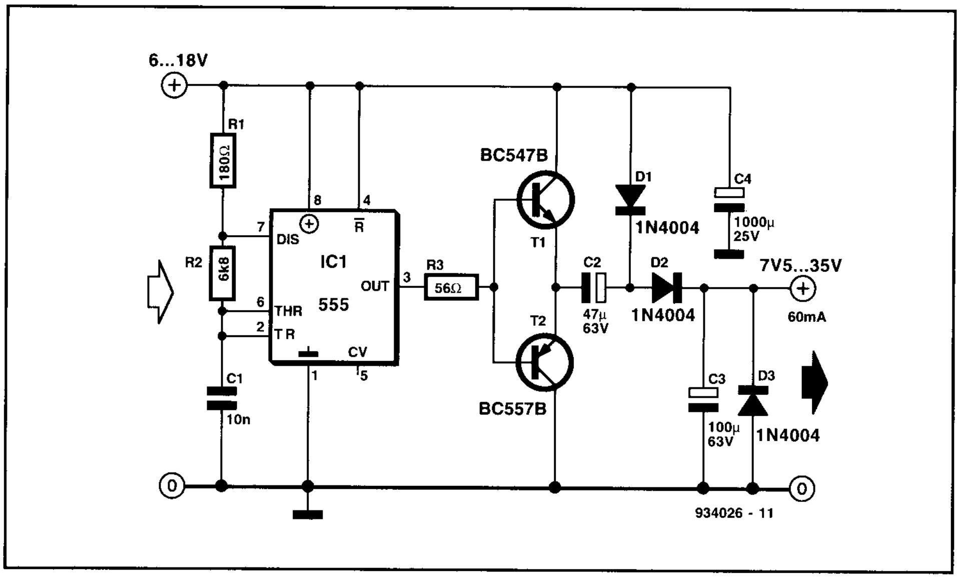
[Amrit bir Tiwana - 934082]

SIMPLE DC TO DC CONVERTER

To keep the converter simple, it contains no preset controls, which means that the level of the output voltage is dependent to some degree on the load. In theory, the output level is twice the level of the input voltage, but, owing to losses in the converter, that level cannot be attained. The main losses occur at the semiconductor junctions of the transistors and the rectifier diodes. Since the drop at these junctions is constant at about 0.6 V, the losses are proportionally larger with an input voltage of 6 V than with one of 18 V.

Oscillator IC_1 generates a signal at a frequency of about 10 kHz. Depending on the output level of the IC, either T_1 or T_2 is switched on. This results in C_2 being charged during one half period; during the other half period, the charge of C_2 is transferred to C_3. This results in the output voltage being twice the input voltage less the losses mentioned.

The circuit contains no critical components; IC_1 may be any version of the 555, bipolar or CMOS, while the transistors may be inexpensive LF types.



Although the present circuit uses 1N4004 diodes, Types 1N4001 will do just as well.

Although the switching frequency is of the order of 10 kHz, and the diodes are designed for lower frequencies, no problems were experienced in the prototype, primarily because the voltages and currents are relatively small.

The converter draws a current of 5 mA (555) plus twice the output current.

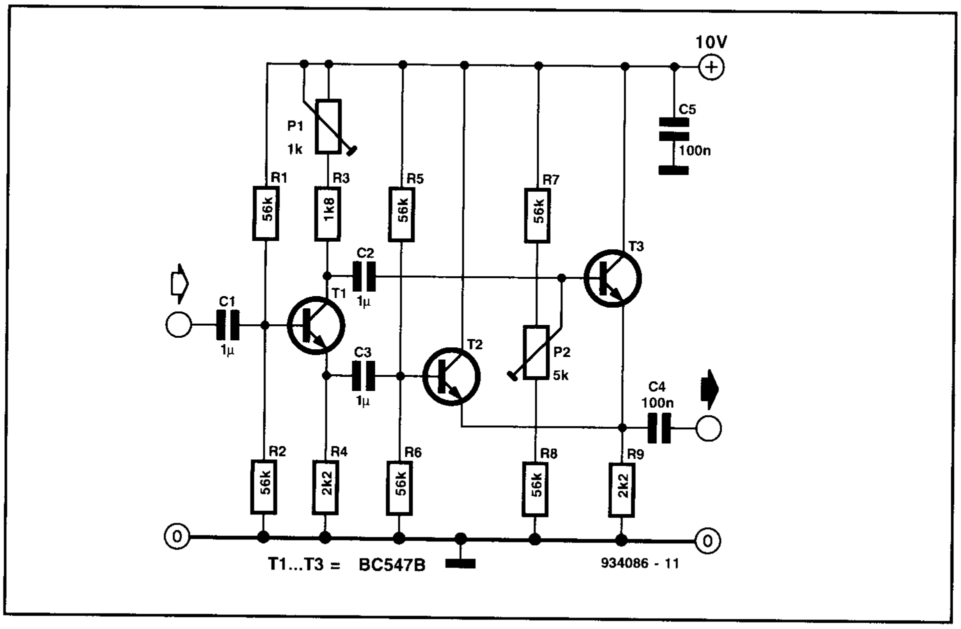
[Amrit Bir Tiwana - 934026]

FREQUENCY DOUBLER

The circuit of the frequency doubler may be looked at from different angles. With input signals ≥1 V, T_2 and T_3 operate as full-wave rectifiers. This means that the fundamental frequency of the input signal is automatically doubled. With input signals <1 V, the two anti-phase signals produced by T_1 from the input signal are applied to the emitters of T_2 and T_3 and summed. This means that the fundamental frequency will virtually disappear, so that, because of non-linearities, only the harmonics remain: the first harmonic will then become the new fundamental frequency in the output signal. This means, of course, that the signal strength reduces appreciably: of an input of 25 mV, only 6 mV remain.

Assuming that the input is sinusoidal, the suppression of the fundamental frequency is optimized with P_1. The operating point of T_3 should be set with P_2 for as near a sinusoidal output as possible. In the protype, the output signal showed a distortion of 5.5% with an input signal frequency of 1 kHz.

The input frequency range is 80 Hz to well over 100 kHz.



Any tendency of T_2 or T_3 to oscillate may be suppressed by soldering a small ceramic capacitor (about 56 pF) between the base and collector of the transistor.

The circuit draws a current of about 4 mA.

[Amrit Bir Tiwana - 934086]

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats,
Tyne & Wear NE30 4PQ
Tel. 091 251 4363 Fax. 091 252 2296

DEPT. EE

74LS-Series

74LS00	**£0.14**
74LS01	**£0.14**
74LS02	**£0.14**
74LS03	**£0.14**
74LS04	**£0.14**
74LS05	**£0.14**
74LS08	**£0.14**
74LS09	**£0.14**
74LS10	**£0.14**
74LS107	**£0.23**
74LS109	**£0.21**
74LS11	**£0.17**
74LS112	**£0.21**
74LS113	**£0.21**
74LS114	**£0.21**
74LS12	**£0.14**
74LS122	**£0.31**
74LS123	**£0.31**
74LS125	**£0.21**
74LS126	**£0.21**
74LS13	**£0.14**
74LS132	**£0.21**
74LS133	**£0.18**
74LS136	**£0.16**
74LS138	**£0.24**
74LS139	**£0.25**
74LS14	**£0.18**
74LS145	**£0.56**
74LS147	**£1.26**
74LS148	**£0.70**
74LS15	**£0.14**
74LS151	**£0.25**
74LS153	**£0.25**
74LS154	**£0.70**
74LS155	**£0.25**
74LS156	**£0.25**
74LS157	**£0.25**
74LS158	**£0.25**
74LS160	**£0.32**
74LS161	**£0.32**
74LS162	**£0.32**
74LS163	**£0.32**
74LS164	**£0.26**
74LS165	**£0.48**
74LS170	**£0.30**
74LS173	**£0.24**
74LS174	**£0.24**
74LS175	**£0.24**
74LS190	**£0.25**
74LS191	**£0.24**
74LS192	**£0.24**
74LS193	**£0.24**
74LS195	**£0.24**
74LS196	**£0.24**
74LS197	**£0.24**
74LS20	**£0.16**
74LS21	**£0.14**
74LS22	**£0.14**
74LS221	**£0.36**
74LS240	**£0.32**
74LS241	**£0.32**
74LS242	**£0.32**
74LS243	**£0.32**
74LS244	**£0.32**
74LS245	**£0.33**
74LS247	**£0.32**
74LS251	**£0.24**
74LS257	**£0.24**
74LS258	**£0.24**
74LS26	**£0.14**
74LS266	**£0.14**
74LS27	**£0.14**
74LS273	**£0.32**
74LS279	**£0.25**
74LS30	**£0.14**
74LS32	**£0.14**
74LS365	**£0.21**
74LS367	**£0.21**
74LS368	**£0.21**
74LS37	**£0.14**
74LS373	**£0.32**
74LS374	**£0.32**
74LS375	**£0.34**
74LS377	**£0.32**
74LS378	**£0.62**
74LS38	**£0.14**
74LS390	**£0.25**
74LS393	**£0.24**
74LS395	**£0.26**
74LS399	**£0.62**
74LS40	**£0.14**
74LS42	**£0.25**
74LS47	**£0.42**
74LS51	**£0.14**
74LS670	**£0.69**
74LS73	**£0.17**
74LS74	**£0.19**
74LS75	**£0.19**
74LS76	**£0.25**
74LS83	**£0.31**
74LS85	**£0.35**
74LS86	**£0.20**
74LS90	**£0.23**
74LS92	**£0.35**
74LS93	**£0.25**

ENAMELLED COPPER WIRE

All 2oz Reels

14 SWG	**£0.63**
16 SWG	**£0.67**
18 SWG	**£0.67**
20 SWG	**£0.72**
22 SWG	**£0.76**
24 SWG	**£0.80**
26 SWG	**£0.89**
28 SWG	**£0.91**
30 SWG	**£0.93**
32 SWG	**£0.93**
34 SWG	**£0.99**
36 SWG	**£1.04**
38 SWG	**£1.10**
40 SWG	**£1.22**

4000 Series

4000	**£0.17**
4001	**£0.17**
4002	**£0.17**
4006	**£0.32**
4007	**£0.17**
4008	**£0.31**
4009	**£0.19**
4010	**£0.23**
4011	**£0.16**
4012	**£0.16**
4013	**£0.17**
4014	**£0.30**
4015	**£0.31**
4016	**£0.18**
4017	**£0.27**
4018	**£0.27**
4019	**£0.19**
4020	**£0.31**
4021	**£0.31**
4022	**£0.32**
4023	**£0.16**
4024	**£0.21**
4025	**£0.15**
4026	**£0.59**
4027	**£0.18**
4028	**£0.22**
4029	**£0.27**
4030	**£0.17**
4031	**£0.70**
4033	**£0.56**
4034	**£1.24**
4035	**£0.31**
4040	**£0.29**
4041	**£0.31**
4042	**£0.22**
4043	**£0.28**
4044	**£0.35**
4046	**£0.31**
4047	**£0.25**
4048	**£0.31**
4049	**£0.20**
4050	**£0.20**
4051	**£0.25**
4052	**£0.25**
4053	**£0.25**
4054	**£0.56**
4055	**£0.34**
4060	**£0.31**
4063	**£0.29**
4066	**£0.18**
4067	**£1.91**
4068	**£0.16**
4069	**£0.20**
4070	**£0.17**
4071	**£0.20**
4072	**£0.17**
4073	**£0.17**
4075	**£0.17**
4076	**£0.30**
4077	**£0.17**
4081	**£0.14**
4082	**£0.17**
4085	**£0.28**
4086	**£0.26**
4089	**£0.55**
4093	**£0.18**
4094	**£0.31**
4095	**£0.56**
4097	**£1.20**
4098	**£0.31**
4099	**£0.38**
4502	**£0.38**
4503	**£0.31**
4508	**£0.90**
4510	**£0.26**
4511	**£0.32**
4512	**£0.32**
4514	**£0.73**
4515	**£0.98**
4516	**£0.31**
4518	**£0.27**
4520	**£0.26**
4521	**£0.62**
4526	**£0.40**
4527	**£0.39**
4528	**£0.40**
4529	**£0.44**
4532	**£0.32**
4534	**£2.24**
4536	**£1.00**
4538	**£0.37**
4541	**£0.33**
4543	**£0.46**
4555	**£0.34**
4556	**£0.34**
4560	**£1.18**
4566	**£1.96**
4572	**£0.25**
4584	**£0.24**
4585	**£0.32**
4724	**£0.70**
40106	**£0.31**
40109	**£0.50**
40163	**£0.46**
40174	**£0.34**
40175	**£0.36**
40193	**£0.60**

OPTO DEVICES

5mm Red LED	**£0.09**
5mm Green LED	**£0.10**
5mm Yellow LED	**£0.10**
5mm Orange LED	**£0.10**
3mm Red LED	**£0.08**
3mm Green LED	**£0.12**
3mm Yellow LED	**£0.13**
3mm Orange LED	**£0.13**
5mm Flashing Red	**£0.50**
5mm Flashing Green	**£0.54**
5mm Bi Colour	**£0.36**
5mm Tri Colour	**£0.48**
5mm Plastic Bezel	**£0.04**
3mm Plastic Bezel	**£0.05**
0.3" 7 Segment Display Red	
common anode	**£1.14**
common cathode	**£1.14**

TRANSISTORS

2N1613	**£0.31**	BC186	**£0.33**	BD534	**£0.47**
2N1711	**£0.26**	BC204C	**£0.72**	BD535	**£0.48**
2N1893	**£0.29**	BC206B	**£0.72**	BD536	**£0.65**
2N2218A	**£0.28**	BC207C	**£0.72**	BD646	**£0.52**
2N2219A	**£0.25**	BC208	**£0.72**	BD648	**£0.52**
2N2222A	**£0.16**	BC209A	**£0.72**	BD650	**£0.53**
2N2646	**£0.80**	BC212	**£0.08**	BD707	**£0.42**
2N2904A	**£0.25**	BC212L	**£0.08**	BD807	**£0.80**
2N2905A	**£0.23**	BC212LB	**£0.08**	BDX32	**£1.78**
2N2907	**£0.20**	BC213	**£0.08**	BDX33C	**£0.46**
2N2926	**£0.16**	BC213LC	**£0.08**	BDX34C	**£0.50**
2N3053	**£0.27**	BC214	**£0.08**	BDX53C	**£0.47**
2N3054	**£0.90**	BC214L	**£0.08**	BDX54C	**£0.50**
2N3055	**£0.62**	BC237B	**£0.09**	BF180	**£0.31**
2N3440	**£0.50**	BC238C	**£0.09**	BF182	**£0.31**
2N3702	**£0.09**	BC239C	**£0.10**	BF185	**£0.31**
2N3703	**£0.10**	BC251	**£0.13**	BF194	**£0.19**
2N3704	**£0.10**	BC252	**£0.13**	BF195	**£0.19**
2N3705	**£0.10**	BC261B	**£0.24**	BF244	**£0.35**
2N3706	**£0.10**	BC262B	**£0.24**	BF257	**£0.33**
2N3771	**£1.44**	BC267B	**£0.30**	BF259	**£0.33**
2N3772	**£1.51**	BC307	**£0.10**	BF337	**£0.36**
2N3773	**£1.79**	BC308	**£0.10**	BF355	**£0.38**
2N3819	**£0.40**	BC327	**£0.10**	BF423	**£0.13**
2N3820	**£0.58**	BC328	**£0.10**	BF451	**£0.19**
2N3904	**£0.10**	BC337	**£0.10**	BF459	**£0.29**
2N3905	**£0.10**	BC338	**£0.10**	BF469	**£0.36**
2N3906	**£0.10**	BC414C	**£0.13**	BFX29	**£0.29**
2N4036	**£0.31**	BC441	**£0.40**	BFX84	**£0.31**
2N5296	**£0.57**	BC461	**£0.40**	BFX85	**£0.31**
2N5321	**£0.57**	BC463	**£0.29**	BFY50	**£0.29**
2N6107	**£0.60**	BC478	**£0.32**	BFY51	**£0.26**
AC126	**£0.30**	BC479	**£0.32**	BFY52	**£0.28**
AC127	**£0.30**	BC490	**£0.24**	BS107	**£0.21**
AC128	**£0.28**	BC516	**£0.22**	BS170	**£0.21**
AC187	**£0.45**	BC517	**£0.20**	BSW66	**£1.35**
AC188	**£0.37**	BC527	**£0.20**	BU126	**£1.70**
ACY17	**£3.84**	BC528	**£0.20**	BU205	**£1.82**
AD149	**£1.67**	BC537	**£0.20**	BU208A	**£1.73**
AD161	**£0.92**	BC546C	**£0.08**	BU326A	**£1.80**
AD162	**£0.92**	BC547C	**£0.09**	BU500	**£2.32**
BC107	**£0.14**	BC548C	**£0.08**	BU508A	**£1.76**
BC107B	**£0.15**	BC549C	**£0.10**	BU526	**£2.24**
BC108	**£0.13**	BC550C	**£0.08**	BU806	**£1.36**
BC108A	**£0.14**	BC556A	**£0.08**	BUX84	**£0.77**
BC108C	**£0.14**	BC557C	**£0.08**	IRF540	**£1.60**
BC109	**£0.14**	BC558C	**£0.08**	IRF740	**£1.63**
BC109C	**£0.15**	BC559C	**£0.08**	MJ11015	**£2.11**
BC114	**£0.41**	BC560B	**£0.09**	MJ11016	**£2.11**
BC115	**£0.41**	BC637	**£0.21**	MJ2501	**£1.60**
BC116	**£0.41**	BC638	**£0.21**	MJ3001	**£1.52**
BC118	**£0.41**	BC639	**£0.21**	MJE340	**£0.40**
BC132	**£0.36**	BC640	**£0.21**	MJE350	**£0.42**
BC134	**£0.36**	BCY70	**£0.21**	MPSA13	**£0.12**
BC135	**£0.36**	BCY71	**£0.20**	MPSA42	**£0.17**
BC140	**£0.25**	BCY72	**£0.20**	MRF475	**£6.21**
BC141	**£0.27**	BD135	**£0.20**	TIP121	**£0.35**
BC142	**£0.31**	BD136	**£0.21**	TIP122	**£0.37**
BC143	**£0.34**	BD137	**£0.22**	TIP125	**£0.37**
BC149	**£0.12**	BD138	**£0.22**	TIP127	**£0.37**
BC154	**£0.36**	BD139	**£0.23**	TIP132	**£0.46**
BC157	**£0.12**	BD140	**£0.24**	TIP137	**£0.46**
BC159	**£0.12**	BD150C	**£0,82**	TIP142	**£1.06**
BC160	**£0.28**	BD165	**£0.42**	TIP147	**£1.12**
BC170	**£0.16**	BD166	**£0.35**	TIP2955	**£0.63**
BC170B	**£0.16**	BD187	**£0.39**	TIP29C	**£0.31**
BC171	**£0.11**	BD201	**£0.40**	TIP3055	**£0.63**
BC171B	**£0.16**	BD202	**£0.40**	TIP30C	**£0.31**
BC172	**£0.13**	BD203	**£0.40**	TIP31C	**£0.32**
BC172B	**£0.13**	BD204	**£0.40**	TIP32C	**£0.32**
BC177	**£0.18**	BD222	**£0.40**	TIP33C	**£0.72**
BC178	**£0.18**	BD225	**£0.42**	TIP41A	**£0.36**
BC179	**£0.17**	BD232	**£0.38**	TIP42C	**£0.38**
BC182	**£0.08**	BD237	**£0.32**	TIP47	**£0.48**
BC182L	**£0.08**	BD238	**£0.32**	TIP48	**£0.62**
BC182LB	**£0.08**	BD240B	**£0.37**	TIP50	**£0.53**
BC183	**£0.08**	BD243B	**£0.50**	VN10KM	**£0.44**
BC183L	**£0.08**	BD244A	**£0.53**	VN66AF	**£1.50**
BC183LB	**£0.08**	BD246	**£1.06**	ZTX300	**£0.16**
BC184	**£0.08**	BD441	**£0.41**	ZTX500	**£0.16**
BC184L	**£0.08**	BD442	**£0.41**		

TRIACS

Z0105DA	**£0.42**
TIC206D	**£0.65**
TIC226D	**£0.73**
BTA08-600B	**£0.84**
TIC236D	**£0.96**
DIAC	**£0.20**

VOLTAGE REGULATORS

78L05	**£0.24**
78L12	**£0.24**
78L15	**£0.24**
79L05	**£0.28**
79L12	**£0.28**
79L15	**£0.28**
7805	**£0.28**
7812	**£0.28**
7815	**£0.28**
7905	**£0.38**
7912	**£0.38**
7915	**£0.38**
LM317T	**£0.44**
LM723	**£0.29**
L200CV	**£1.16**
LM323K	**£2.70**
LM338K	**£5.52**

THYRISTORS

PO102AA	**£0.30**
TIC106D	**£0.40**
TIC116D	**£0.66**
TIC126D	**£0.77**

HARDWARE

T2 Box 75 x 56 x 25mm	**£0.82**
T3 Box 75 x 51 x 25mm	**£0.82**
T4 Box 111 x 57 x 22mm	**£0.98**
MB1 Box 79 x 61 x 40mm	**£1.44**
MB2 Box 100 x 76 x 41mm	**£1.56**
MB3 Box 118 x 98 x 45mm	**£1.82**
MB5 Box 150 x 100 x 60mm	**£2.50**

ELECTROLYTIC RADIAL CAPACITORS

uF	16V	25V	63V	100V	450V
0.47	–	–	**£0.05**	**£0.07**	–
1.0	–	–	**£0.05**	**£0.06**	**£0.15**
2.2	–	–	**£0.05**	**£0.06**	**£0.18**
4.7	–	–	**£0.05**	**£0.08**	**£0.30**
10	**£0.05**	**£0.05**	**£0.06**	**£0.08**	**£0.48**
22	**£0.05**	**£0.05**	**£0.09**	–	–
47	**£0.06**	**£0.06**	**£0.11**	–	–
100	**£0.06**	**£0.09**	**£0.11**	–	–
220	**£0.09**	**£0.12**	**£0.31**	–	–
470	**£0.15**	**£0.19**	**£0.57**	–	–
1000	**£0.22**	**£0.29**	–	–	–
2200	**£0.37**	**£0.57**	–	–	–
4700	–	**£1.11**	–	–	–

ELECTROLYTIC AXIAL CAPACITORS

uF	16V	25V	63V	100V	450V
0.47	–	–	–	**£0.15**	–
1.0	–	–	**£0.10**	**£0.10**	**£0.19**
2.2	–	–	**£0.10**	**£0.10**	**£0.22**
4.7	–	**£0.09**	**£0.10**	**£0.10**	**£0.34**
10	–	**£0.12**	**£0.12**	**£0.12**	**£0.48**
22	–	**£0.09**	**£0.13**	**£0.17**	**£1.06**
47	**£0.10**	**£0.11**	**£0.16**	**£0.20**	**£1.33**
100	**£0.10**	**£0.13**	**£0.21**	–	**£2.46**
220	**£0.13**	**£0.18**	**£0.42**	–	–
470	**£0.21**	**£0.24**	**£0.69**	–	–
1000	**£0.33**	**£0.40**	**£1.05**	–	–
2200	**£0.52**	**£0.64**	–	–	–
4700	**£0.90**	–	–	–	–

LINEAR ICs

CA311E	**£0.28**
CA324	**£0.23**
CA555	**£0.22**
CA741CE	**£0.18**
CA747CE	**£0.39**
CA3046	**£0.37**
CA3080	**£0.72**
CA3130	**£0.98**
CA3130E	**£0.98**
CA3140	**£0.56**
CA3240	**£1.22**
ICL7621	**£1.70**
ICM7555	**£0.43**
ICM7556	**£0.96**
LM301A	**£0.25**
LM348N	**£0.31**
LF351N	**£0.36**
LF353	**£0.41**
LM358N	**£0.27**
LM377	**£2.57**
LM380N	**£1.12**
LM381	**£2.70**
LM386	**£0.48**
LM387	**£1.60**
LM392N	**£0.79**
LM393N	**£0.28**
LM748CN	**£0.31**
LM1458	**£0.26**
LM3900	**£0.72**
LM3914	**£2.70**
LM3915	**£2.70**
MC3340	**£1.60**
MC4558	**£0.36**
NE531	**£1.56**
NE556N	**£0.36**
NE567N	**£0.36**
NE5532	**£0.80**
NE5534	**£0.66**
TBA120S	**£0.77**
TBA810S	**£0.68**
TBA820M	**£0.39**
TDA2030	**£1.35**
TL061	**£0.35**
TL062	**£0.42**
TL064	**£0.46**
TL071CP	**£0.32**
TL072CP	**£0.34**
TL074CN	**£0.48**
TL081	**£0.33**
TL082CP	**£0.34**
TL084CN	**£0.46**
UA733	**£0.64**
ULN2004	**£0.48**
ZN414Z	**£1.04**
ZN425E	**£4.68**
ZN426E	**£2.61**
ZN427E	**£8.82**
ZN428E	**£6.12**
ZN435E	**£5.31**
ZN448E	**£7.92**

EPROMS & RAMS

2716	**£4.46**
2732	**£4.84**
2764-25	**£3.00**
27C64-25	**£2.80**
21728-20	**£3.69**
27C128-20	**£3.31**
27256-20	**£3.15**
27C256-20	**£3.55**
27C512	**£3.69**
27C010	**£4.97**
6116-10	**£1.53**
6264-10	**£3.06**
62256-10	**£4.83**
4164-15	**£1.78**
41256-10	**£2.80**
511000-8	**£5.61**
514256-8	**£5.61**

DIL SOCKETS

8 Pin	**£0.07**
14 Pin	**£0.11**
16 Pin	**£0.15**
18 Pin	**£0.15**
20 Pin	**£0.16**
24 Pin	**£0.19**
28 Pin	**£0.22**
40 Pin	**£0.25**

SOLDERING IRONS

Antex Soldering irons	
M 12 Watt	**£7.75**
C 15Watt	**£7.78**
G 18Watt	**£7.96**
CS 17Watt	**£7.88**
XS 25Watt	**£7.96**
ST4 STAND	**£2.85**
35Watt Gas Iron	**£11.58**
Desolder Pump	**£3.00**
Antistatic Pump	**£4.30**
22SWG 0.5Kg Solder	**£7.40**
18SWG 0.5Kg Solder	**£6.60**
1mm 3 yds Solder	**£0.62**
Desolder Braid	**£0.87**

RF CONNECTORS

BNC Solder Plug 50R	**£0.93**
BNC Solder Plug 75R	**£0.96**
BNC Crimp Plug 50R	**£0.68**
BNC Crimp Plug 75R	**£0.68**
BNC Solder Skt	**£1.08**
BNC Chassis Skt	**£0.80**
PL259 5.2mm	**£0.68**
PL259 11mm	**£0.62**
RND UHF socket	**£0.68**
SQR UHF socket	**£0.45**
F Plug RG58	**£0.30**
F Plug RG6	**£0.27**
N Plug RG8	**£1.60**
N Socket RG8	**£1.40**
BNC Crimp Pliers	**£15.50**

PCB EQUIPMENT

UV EXPOSURE UNIT	**£67.38**
PLASTIC DEVELOPING TRAY	**£1.35**
PHOTO RESIST AEROSOL SPRAY (100ml)	**£3.90**
FERRIC CHLORIDE CRYSTALS (0.5Kg)	**£2.45**
TIN PLATING POWDER (90g)	**£10.80**
ETCH RESIST PEN	**£0.72**
PCB POLISHING BLOCK	**£1.84**

STRIPBOARD 0·1 PITCH

64mm x 25mm	**£0.27**
64mm x 95mm	**£0.90**
64mm x 431mm	**£3.22**
95mm x 127mm	**£1.50**
95mm x 95mm	**£1.10**
95mm x 431mm	**£4.80**
100mm x 160mm	**£1.60**
119mm x 454mm	**£6.20**

BREADBOARD

81mm x 60mm	**£3.06**
175mm x 42mm	**£3.74**
175mm x 67mm	**£5.56**
203mm x 75mm includes mounting plate & posts	**£7.36**

COPPER BOARD (G. Fibre)

100mm x 160mm	**£0.90**
110mm x 220mm	**£1.24**

PHOTO RESIST BOARD (G. Fibre)

3" x 4"	**£0.86**
4" x 6"	**£1.62**
4" x 8"	**£2.09**
6" x 6"	**£2.41**

PHOTO RESIST BOARD (Paper)

3" x 4"	**£0.67**
4" x 6"	**£1.24**
4" x 8"	**£1.58**
8" x 10"	**£4.63**

CAPACITORS

Ceramic Mini Disc 100 & 63V
1.0pF to 100nF
1pF-1nF **£0.06**, 1n2-2n7 **£0.07**,
3n3-4n7 **£ 0.12**,
10n & 12n **£0.07**
Polystyrene 160V 5% 47pF to 10nF
47p-2n2 **£0.09**, 2n7-10n **£0.12**

D CONNECTORS

	Plug	Socket
9 Pin	**£0.29**	**£0.30**
15 Pin	**£0.39**	**£0.39**
15 Pin H.D.	**£0.81**	**£0.90**
23 Pin	**£0.40**	**£0.49**
25 Pin	**£0.48**	**£0.50**
9 Way plastic cover		**£0.30**
15 Way plastic cover		**£0.33**
23 Way plastic cover		**£0.36**
25 Way plastic cover		**£0.36**

BRIDGE RECTIFIERS

W005 1.5A 50V	**£0.19**
WO2 1.5A 200V	**£0.20**
BR32 3A 200V	**£0.36**
BR62 6A 200V	**£0.64**
1004 10A 400V	**£1.39**

SWITCHES

3amp 250v 6.4mm ϕ mounting	
SPST Toggle	**£0.58**
SPDT Toggle	**£0.60**
SPDT CO Tog	**£0.64**
DPDT Toggle	**£0.68**
DPDT CO Toggle	**£0.76**
DPDT CO Toggle (biased)	**£1.20**
DPDT CO Toggle (biased 1 way)	**£1.20**
DPDT mini slide	**£0.15**
Rotary Wafer 1P-12W, 2P-6W, 3P-4W, 4P-3W	**£0.78**
Key Switch SPST	**£2.70**
Push to make	**£0.25**
Push to break	**£0.28**
Latching Push Sqr	**£0.63**
PCB Tact 6 x 6mm	**£0.25**

RESISTORS

0.25W 5% CF E12 Series	**£0.60**/100
0.5W 5% CF E12 Series	**£0.95**/100
0.25W 1% MF E24 Series	**£1.72**/100
POTS Log or Lin 470R – 1MO 25mm dia 0.25in shaft	**£0.42**
PRESETS Enclosed Horz or Vert 100R – 1MO 0.15W	**£0.15**
PRESETS Skeleton Horz or Vert 100R – 1MO 0.1W	**£0.11**

★ PLEASE STATE VALUE REQUIRED ★

COMPUTER ACCESSORIES

Parallel Printer Lead 2m	**£6.90**
RS232 Lead (all pins) Male – Male	**£3.60**
RS232 Lead (all pins) Female – Male	**£3.60**
Centronics 36 Way Lead Male – Male	**£4.78**
Gender Changers	
9 Way D Mini Female to Female	**£1.81**
9 Way D Mini Male to Male	**£1.98**
25 Way D Mini Female to Female	**£2.23**
25 Way D Mini Male to Male	**£2.23**
9 Way D Female to Female	**£2.33**
9 Way D Male to Male	**£2.33**
25 Way D Female to Female	**£2.71**
25 Way D Male to Male	**£2.71**
Adaptors	
9 Way Male to 25 Way Female	**£2.33**
25 Way Male to 9 Way Female	**£2.33**
25 Way D Male to 36 Way Centronic	**£3.56**
25 Way Null Modem Female – Female	**£3.02**
25 Way Null Modem Male to Female	**£3.02**
25 Way Null Modem Male to Male	**£3.02**
RS232 Surge Protector Male - Female	**£6.12**
RS232 Jumper Box Male to Female	**£3.02**
RS232 Tester (7 LEDs) Male – Female	**£6.59**
Data Switch Boxes	
Serial Switch box – 2 Way A/B	**£9.20**
Serial Switch box – 3 Way A/B/C	**£13.16**
Serial Switch box – 4 Way A/B/C/D	**£15.15**
Serial Switch box – Cross over	**£19.69**
Parallel box – 2 Way A/B	**£11.84**
Parallel box – 3 Way A/B/C/	**£17.11**
Parallel box – 4 Way A/B/C/D	**£18.43**
Parallel box – Cross over	**£20.42**

DIODES

Zener Diodes 2V7–33V	
BZY88400Mw	**£0.08**
BZX85 1.3W	**£0.14**
1N4001	**£0.06**
1N4002	**£0.07**
1N4003	**£0.07**
1N4004	**£0.07**
1N4005	**£0.07**
1N4006	**£0.08**
1N4007	**£0.08**
1N5400	**£0.09**
1N5401	**£0.09**
1N5402	**£0.09**
1N5404	**£0.11**
1N5406	**£0.11**
1N5407	**£0.14**
1N5408	**£0.15**
1N914	**£0.06**
1N916	**£0.06**
1N4148	**£0.05**
BY133	**£0.13**
OA47	**£0.28**
OA90	**£0.07**
OA91	**£0.10**
OA202	**£0.27**
BA157	**£0.10**
BA158	**£0.10**
BA159	**£0.10**
1N4149	**£0.06**
OA200	**£0.10**

ORDERING INFORMATION

All prices exclude VAT.
Please add £1.25 carriage to all orders and VAT (17.5%).
No minimum order charge.
Free Computer listing with all orders over £5.00.
Please send payment with your order.
PO/Cheques made payable to
ESR Electronic Components
Access & Visa cards accepted
Offical orders from schools & colleges welcome.

VISA

CALL IN – OPEN: MON-FRI 8.30-5.00 SAT 10.00-5.00

WIND DIRECTION INDICATOR

The indicator shows eight wind directions by means of LEDs. The sensors are reed contacts powered by a permanent magnet. The mechanical construction must be such that it is impossible for more than one reed contact to be closed at any one time.

At the instant a reed contact closes, a leading transition (edge) is applied to the clock inputs of D-bistables (flip-flops) IC_2 and IC_3 via an OR gate in IC_1. This results in the outputs of the bistables assuming the status of the D inputs, so that only the LED associated with the closed reed contact lights.

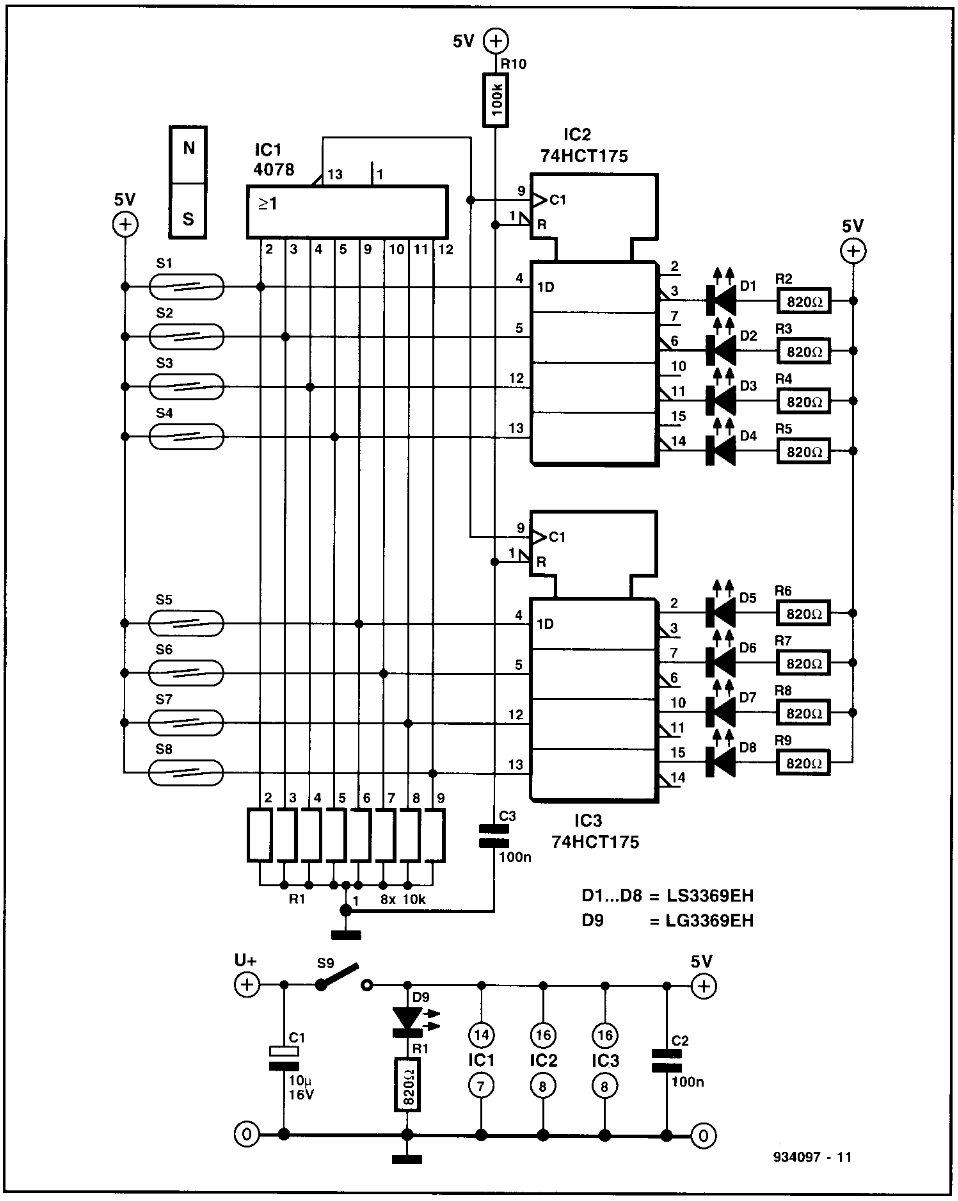
If the wind changes direction slightly, and the reed contact opens, then, owing to the bistable construction, the LED will continue to light. Only when the wind has changed direction so much that another reed contact closes will a different LED light.

When the supply voltage is switched on (S_1), only D_9 will light owing to the power-on reset via R_{10} and C_3. Only when one of the reed contacts has caused a leading transition (edge) at the clock inputs will one of the direction LEDs (D_1–D_8) light.

The indicator needs to be supplied by a regulated 5 V source. It draws a current of not more than 10 mA.

The LEDs are low-current Siemens types.

[J. Ruiters - 934097]



REGULATOR SHORT-CIRCUIT INDICATOR

Modern integrated voltage regulators are protected against short circuits, but do not give an indication when a short circuit occurs. In the case of regulators with fixed output (78xx) a short-circuit indicator is easily arranged by connecting an LED and series resistor across the regulator output. The LED will light only during normal operation, that is, input available and output not short-circuited.

If this sort of indicator is used with regulators with a variable output, such as the LM317, the brightness of the LED will vary with the set output. To make the brightness constant, the current through the LED must become independent of the output voltage. The LED current must then not be limited by a series resistor but by a current source. Such a source can be made with only one extra component: T_1 in the circuit diagram.

The design makes use of the available reference voltage across R_1. This voltage is generated by the LM317 and serves in the first instance, in conjunction with R_1, R_2 and P_1, to regulate the output voltage.

In the present circuit, the reference voltage is used to keep the drop across R_3 constant:

$$U_{R3} = 1.25 - U_{eb} = 1.25 - 0.65 = 0.6 \text{ V}.$$

The current through D_3 is then 0.6/180 = 3.3 mA, which is more than ample for the low-current LED used here.

On the prototype, the LED current remains constant with output voltages from 3 V to 25 V. In other words, over that range of voltages, the LED lights with constant brightness.

The base current of T_1 is only 15 µA, so that the operation of the regulator is not affected by the branching off of the reference voltage.

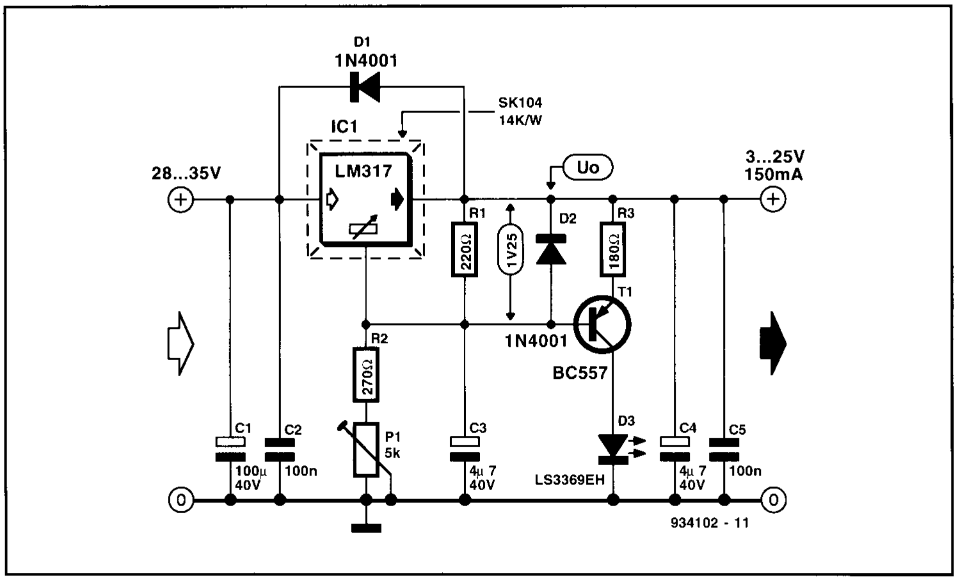
In the present circuit, T_1 dissipates only 100 mW when the collector-emitter voltage is 25 V. Since this transistor can dissipate up to 500 mW (with heat sink), overheating is highly unlikely. Also, its collector-emitter voltage of 25 V is well below the maximum permissible 45 V. These limits should be borne in mind, however, if the power supply provides higher output voltages.

Capacitor C_3 increases the ripple suppression from 65 dB to 80 dB. Diode D_2 protects IC_1 and T_1 against too high a discharge current from C_3 and too high a base-emitter reverse bias (max. 5 V) when the regulator is short-circuited.

Diode D_1 protects the regulator against discharge currents from C_4 and any electrolytic capacitors in the circuit being supplied). Without this diode, these capacitors would discharge through the regulator should the input of this IC be short-circuited or be connected to a lower voltage.

The quiescent current of the indicator circuit is about 10 mA, while the peak current may rise to 1.5 A. At maximum input voltage (35 V) and minimum output voltage (3 V), the circuit can provide a constant current of about 150 mA.

[J. Ruiters - 934102]



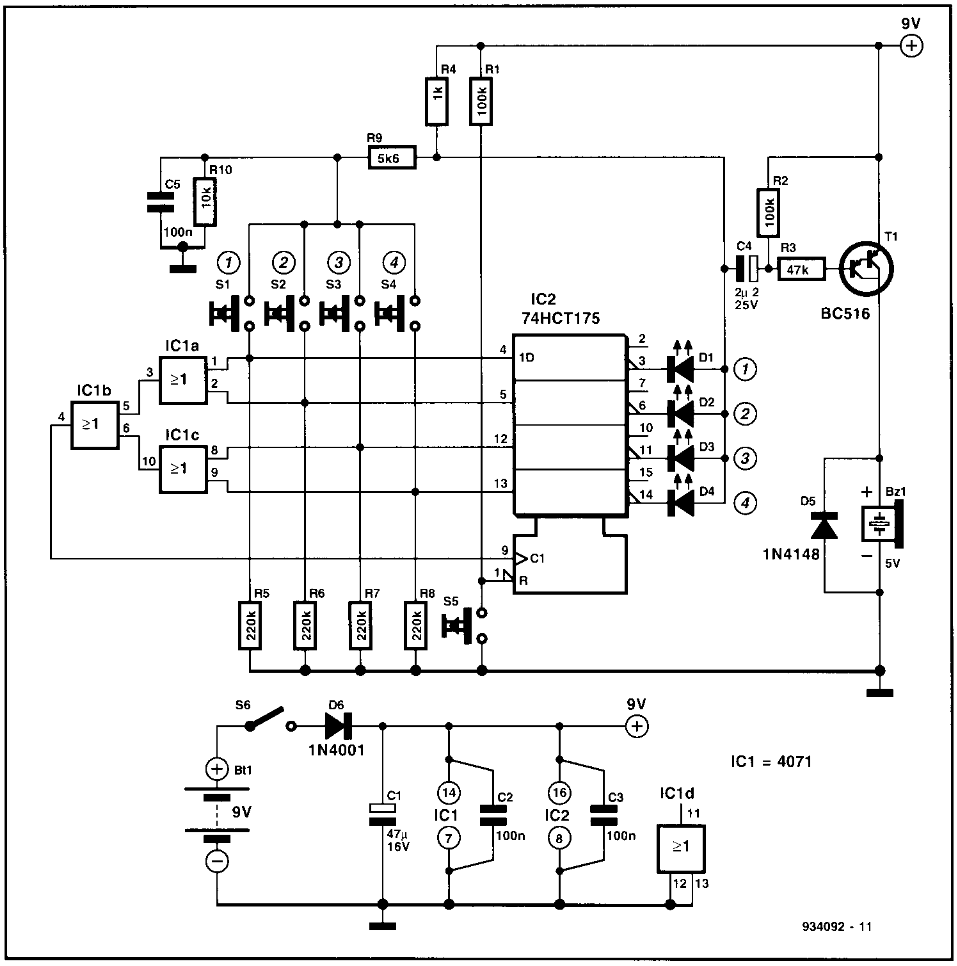
PRECEDENCE DETECTOR

The detector was designed primarily for use with quiz games. It indicates who has first pressed a push button by the sounding of a buzzer and the lighting of an LED. The quiz master can then reset the detector.

In the diagram, the four push buttons, S_1–S_4, are connected to the D inputs of four bistables contained in IC_2. They are also connected to the clock input of IC_2 via OR gates IC_{1a}, IC_{1b} and IC_{1c}. The Q outputs of the bistables drive D_1–D_4.

After the bistables have been reset with S_5 (which briefly makes the CLR input low), all Q outputs are high, so that the LEDs are out. If one of the push-buttons, say S_1, is pressed, a high level ensues at the associated D input. This high level is applied to the clock input of all bistables, whereupon the existing levels at the D inputs of the bistables are stored and applied to the outputs; D_1 will then light

Since the switches and the LEDs are connected to the supply line via a common resistor, R_4, the voltage at points after R_4 will drop to about 2 V owing to the lighting of D_1. Because of potential divider R_9-R_{10}, the voltage across the switches will be only about 1 V. If then one of the switches, other than S_1, is pressed, the voltage at the associated D input(s), as well as at the clock input, will be too low for the IC to react. In this way, the circuit is disabled after one of the switches has been pressed.



Darlington T_1 drives the d.c. buzzer. The base of T_1 is connected to the anodes of the LEDs via R_3 and C_4. At the instant one of the LEDs lights, C_1 passes this low level to T_1, which then energizes the buzzer. After about 0.5 s, C_4 is recharged via R_2 and R_3, so that T_1 is switched off.

The circuit draws a current of about 5 mA when the LEDs are out. When one of the LEDs lights and the buzzer sounds, the current rises to some 50 mA.

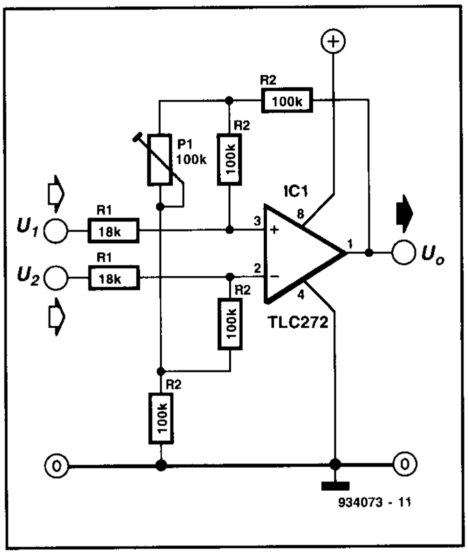
[D. Ibrahim - 934092]

VARIABLE DIFFERENTIAL AMPLIFIER

In a traditional differential amplifier with feedback to the –ve (inverting) input of an operational amplifier and a potential divider at the +ve (non-inverting) input, it is tricky to make the amplification variable. This is because the feedback network and the potential divider need to be each other's image to ensure satisfactory suppression of the common-mode signals (common-mode rejection ratio – CMRR). This means that there must be two variable resistors and these must at all times be equal.

This is not necessary with the present circuit in which one preset can arrange the amplification without affecting the CMRR. It has the following transfer function:

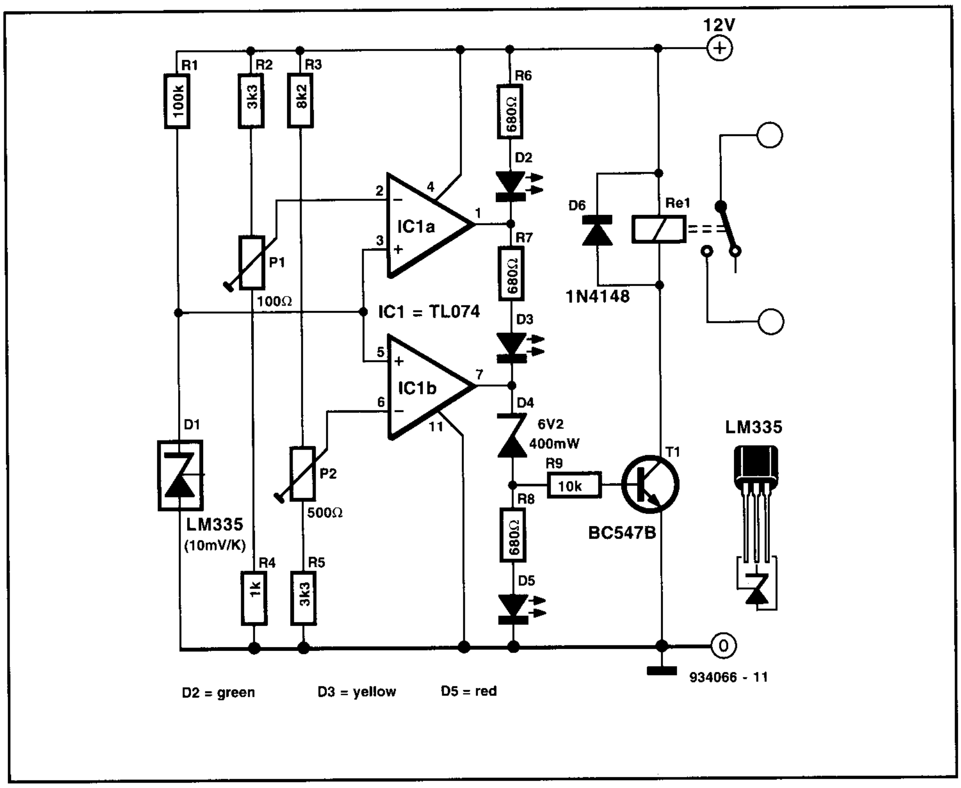
$$U_o = 2R_2/R_1(1+R_2/P_1)(U_2-U_1) \qquad [V]$$



It is clear from this that only P_1 affects the difference voltage U_2–U_1. The common-mode signal does not appear in the function. This is partly because P_1 has no effect on it and partly because the resistors with the same circuit reference also have the same value. In theory, that gives total rejection of common-mode signals; in practice, tolerances of the components used will determine the CMRR. To calculate that, however, the formula will have to be expanded appreciably.

[L. Lemmens - 934073]

TEMPERATURE MONITOR



The monitor is intended for use in relatively small spaces (like living rooms). The sensor is a readily available LM335 from National Semiconductor. This gives an output voltage of 10 mV °C^{-1}. This voltage is compared in IC_{1a} and IC_{1b} with two reference voltages. One of these is preset with P_1 and the other with P_2. The output of the comparators is used to switch D_2, D_3 and D_5.

When the voltage produced by D_1 is smaller than either of the reference potentials, the outputs of IC_{1a} and IC_{1b} are low: D_2 will then light.

When the ambient temperature rises, the output of D_1 rises proportionally. When the level of the sensor output lies between the two reference levels, the output of IC_{1a} is high and that of IC_{1b} is low. Diode D_3 will then light, showing that the critical temperature has been reached.

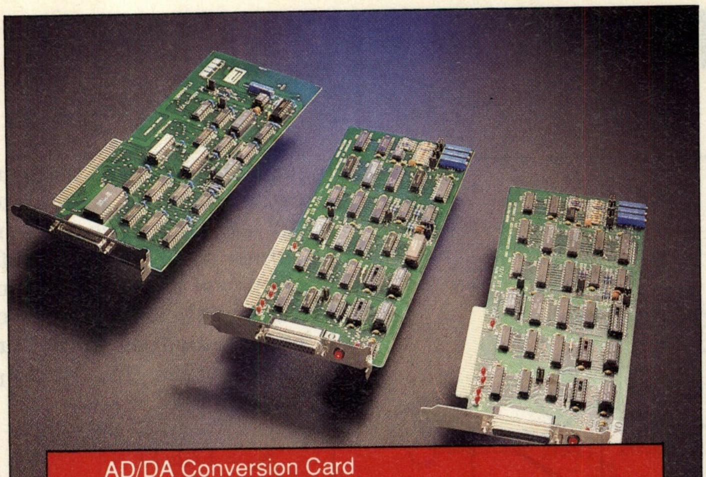
At even higher temperatures, the output of IC_{1b} will also go high and D_5 lights, while the other two LEDs go out. At the same time, the relay will be energized via T_1. The relay contact may then actuate an external load (e.g., a buzzer).

Zener diode D_4 ensures that T_1 does not come on when D_3 lights (since the output voltage of IC_{1b} then rises slightly owing to the current through this IC).

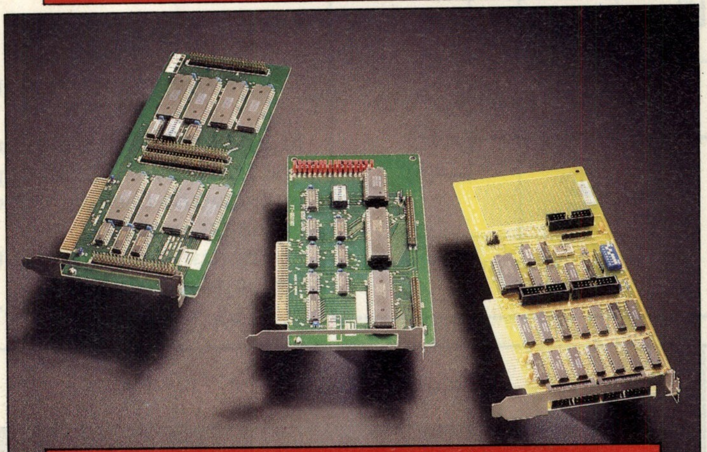
The temperature at which the LEDs should light may be set with P_1 and P_2. Bear in mind, however, that the monitor is intended for 'normal' temperatures between 25 °C and 100 °C.

The monitor draws a current of about 20 mA; when the relay is energized, this rises to about 50 mA.

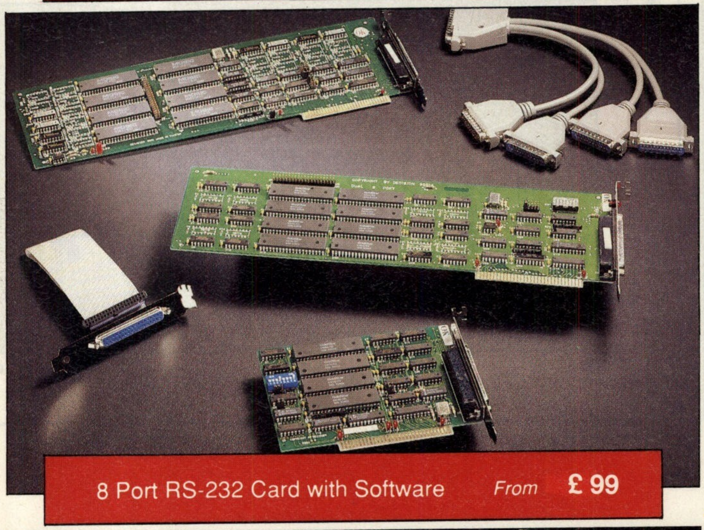
[M. Stehouwer - 934066]



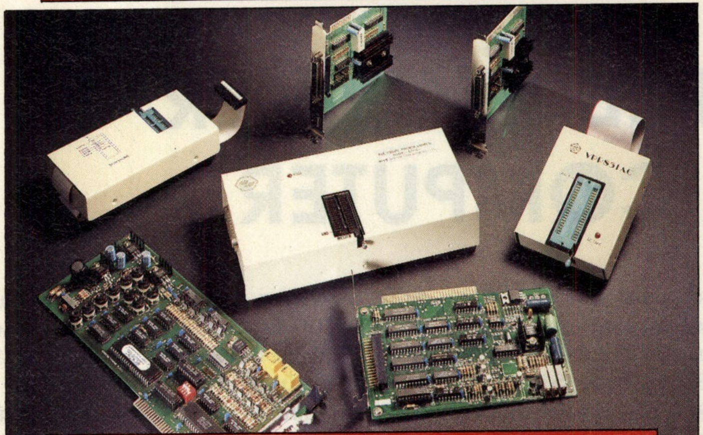
AD/DA Conversion Card
12 Bit Res, 16 Channels I/P *From* **£ 49**



Digital I/O Cards *48 Programmable I/O Lines*
(3 Independent 16 Bit Counters) *From* **£ 29**

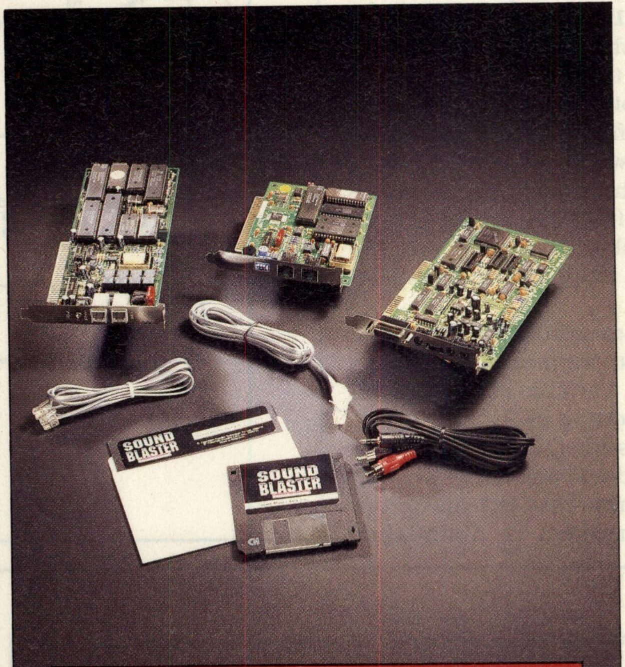


8 Port RS-232 Card with Software *From* **£ 99**



All in one Programmers *From* **£ 395**

Roline
Systems Ltd



Voice Communications Card
Intelligent Telephone Card *From* **£ 175**

PC Based Industrial and Lab, Data Acquisition, Control and Measurement, Instrument Cards

- AD/DA Cards
- Plus Accessories & Software
- C.P.U. Boards
- Device Programmers
- Digital I/O Cards
- I EEE 488 Cards
- Industrial Chassis
- Industrial Control Cards
- Interface Converters
- Relay Output Cards
- RS 232 Cards
  - Single, 2, 4, 8, 16 Port
- RS 422 Cards
  - Single, 2, 4, 8, Port
- PC ROM Disk Cards
- Slot Extender Cards

Specialist PC & Multimedia Add-on Cards

- PC - Telecommunication Cards
- Fax Modem Cards
- Voice Recognition Cards
- Voice Digitiser Cards
- Video/TV - PC - Video/TV Cards
- Sound Cards

VISA ACCESS

Components

- Cases
- Floppy Disk Drives
- Hard Disk Drives
- From 40MB to 2.1GB
- Keyboards
- Monitors
- Mother Boards
- Cache Controller Cards
- Network Cards
- Tape Back Up Units

For further information, Product/Price List
Call Us On:

Tel: 0902 20267 Fax: 0902 28439
Roline Systems Ltd, Imex House,
Imex Business Park, Upper Villiers Street,
Wolverhampton, West Midlands. WV2 4NU

SPECIAL BAND-STOP FILTER

Double T filters are used in many circuits. This type of filter can be made into a perfect band-stop filter, at least in theory. In the present circuit (**Fig. 1**), a double T filter is used in a different manner. It can have the characteristic of the combination of either a band-stop filter and a low-pass filter (switch S_1 in position 1) or a high-pass filter and a band-stop filter (S_1 in position 2). The characteristic curves are given in **Fig. 2** and **3** respectively.

The variable K in **Fig. 2** and **3** is determined by the setting of P_1. Variable M depends on the setting of P_2, and determines the Q factor.

A drawback of the present design is that the maximum suppression is diminished slightly. At $M = 0.75$, maximum attenuation is (calculated) 50 dB. With components values as in **Fig. 1**, the frequency at that attenuation is 1 kHz. Other frequencies can be computed easily. The band-stop frequency, f_{bs}, with S_1 in position 1 is

$$f_{bs} = 1/2\pi RCK. \qquad [Hz]$$

With S_1 in position 2,

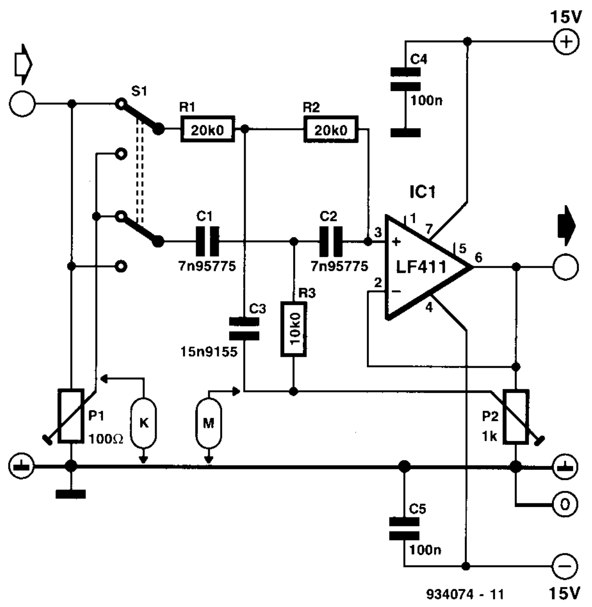
$$f_{bs} = K/2\pi RC. \qquad [Hz]$$

In all cases, $0 \leq K \leq 1$; C is in farad and R is in ohms. Various types of IC may be used for the operational amplifier.

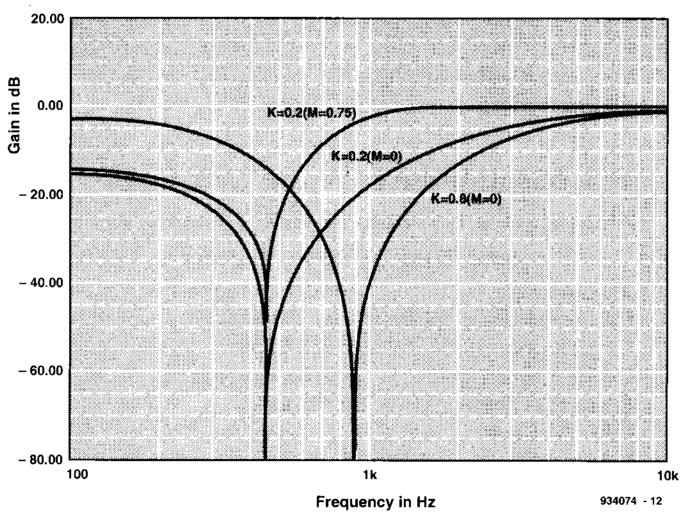
The current drawn by the circuit is around 2 mA.

[A. v.d. Veene - 934074]

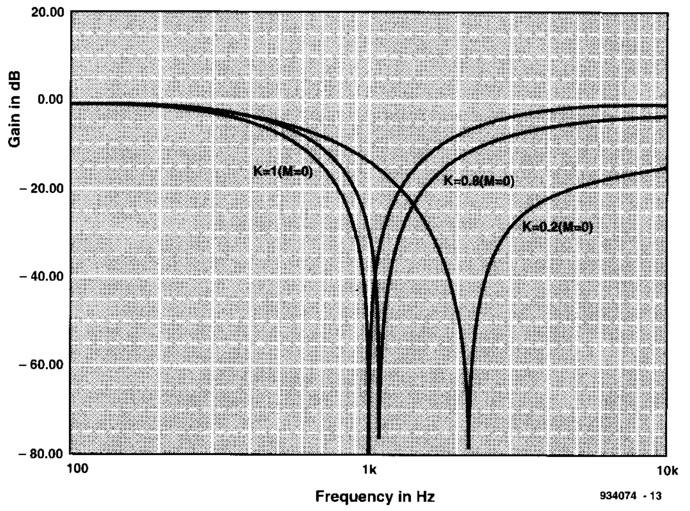
1



2



3



RC-5 INFRA-RED RECEIVER FOR 80C32 COMPUTER

RC-5 is the Philips/Sony standard for infra-red [IR] remote control of audio /video equipment (**Ref. 1**). The circuit and the listing given enable the 80C32 single-board computer (**Ref. 2**) to receive and process IR command signals sent by an RC-5 compatible IR remote control unit.

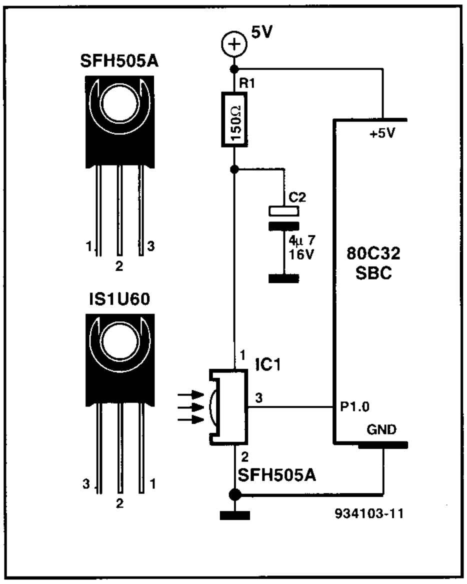
The hardware consists of a Siemens SFH505A IR detector connected directly to the P1.0 port line of the 80C32 microcontroller. The Sharp Type IS1U60 IR detector may be used as an alternative to the SFH505A, with the advantage of higher sensitivity thanks to a pass-band that is better 'tuned' to RC-5 signals*. Note, however, that the SFH505A and the IS1U60 have different pin connections. The IR detector supplies an inverted output signal (high level when no IR signal is detected), which has certain ramifications for the software.

The program (see listing) makes use of the EMON51 monitor program (**Ref. 3**).

Since all timings are based on software, it is essential that the 80C32 computer runs at a clock speed of 12 MHz. It should also be connected to a PC or a terminal, and have the EMON51 system monitor in EPROM. The LOOP routine ensures that the decoding always begins at the start of a new code. COUNT is the count loop proper. If P1.0 goes low during the wait time, R_6 is reset, and the waiting starts again.

Next, a number of registers are initialized to prepare for the reception of a new code, and the software waits for the first high-to-low transition. Note, however, that a half bit time of the new word has already elapsed when this H-to-L transition is actually detected. This means that $^{1}/_{4}$ bit time of the second start bit has elapsed after waiting $^{3}/_{4}$ bit time. Next, the level at P1.0 is monitored twice every bit time — first at $^{1}/_{4}$, and again at $^{3}/_{4}$ of the bit time. The bi-phase modulation used allows the microprocessor to determine if a '0' or a '1' is meant.

Actually, it is sufficient if a 'check' is carried out only once every bit time. If the synchronization is all right, and the check is made at $^{1}/_{4}$ of the bit time, the correct value is established automatically (remember that the input signal is inverted). Checking two times during every bit period, however, enables the software to flag receive errors.



The received bits are shifted into a 16-bit register formed by R4 (low) and R5 (high). The second start bit becomes the MSB. When the received word is complete, the two lowest system address bits are moved from R4 to the LSBs of R5, which leaves the six databits in R4, and the system address bits in the lowest five bits of R5.

Routine CTRL checks if the check bit has changed since the last decoding action. If so, the software decides that a new key has been pressed, or the same key has been pressed again, whereupon the RC-5 system address (that is, the equipment identification number) and the data (that is, the control action required) are sent to the PC. If not, the program jumps back to the start. By omitting the JZ LOOP instruction, the address and data are transmitted on every received code ('auto repeat').

(K.D. Gens — 934103)

***References*:**

1. Universal RC5 code infrared receiver. *Elektor Electronics* January 1992

2. 8051/80C32 single-board computer. *Elektor Electronics* May 1991.

3. 8051/8032 Assembler course (8 instalments). *Elektor Electronics* February to November 1992.

* The IS1U60 detector is available from Hero Electronics Limited, Dunstable Street, Ampthill, Beds MK45 2JS. Telephone: (0525) 405015. Fax: (0525) 402383.

```
; 8032 RC5 decoder using EMON51

; SFR addresses
ACC                     EQU             00E0H
B           EQU             00F0H
P1          EQU             0090H

; EMON51 routines
ccCHR                   EQU             0001H                   ; send character
to PC
ccBYTE      EQU             0003H           ; send byte to PC
command     EQU             0030H           ; EMON51 command register
MON                     EQU             0200H                   ;EMON51 jumpad-
dress

            ORG             4100H           ; program start address

; LOOP waits for 1.5 bit times HIGH signal to ensure that the
; received RC5 signal starts at the start bits. SFR R6 is reset
; if a LOW level is received during this wait cycle.
LOOP                    MOV             R6,#0                   ; 255 x 14 µsec
COUNT                   MOV             A,P1
            ANL             A,#1
            JZ              LOOP            ; no RC5 code received
            MUL             AB              ; wait 4 cycles
            MUL             AB              ; wait 4 cycles
            DJNZ            R6,COUNT

; Receiver ready to detect and decode an incoming RC5 signal

; count 13 bits, ignore first start bit
WORD                    MOV             R7,#13
            MOV             R5,#0           ; reset address
            MOV             R4,#0           ; and data register
; H-to-L edge detected after the first bit half of the start
bit.
HIGH                    JB              P1.0,HIGH   ; wait for H-to-L edge
            MOV             A,#110      ; wait 1/4th bit time
            LCALL           WAIT
            MOV             A,#220      ; wait 1/2 bit time
            LCALL           WAIT
NXTBIT      MOV             A,P1            ; input 1st half 2nd bit
            ANL             A,#1            ; mask bit 0 (=P1.0)
            MOV             R6,A            ; store bit
            MOV             A,#220      ; wait 1/2 bit time
            LCALL           WAIT
            MOV             A,P1            ; input 2nd half 2nd bit
            ANL             A,#1

            CLR             C
; Compare first and second half bit:
;    L-to-H change = HIGH-bit
;    H-to-L change = LOW-bit
            SUBB            A,R6

; if 1st and 2nd bit halves are equal: ERROR!!
            JZ              LOOP
            MOV             A,R4            ; get data register
            RLC             A               ; carry to data register
            MOV             R4,A            ; store data
            MOV             A,R5            ; get address register
            RLC             A               ; shift and
            MOV             R5,A            ; store
            MOV             A,#218      ; wait 1/2 bit time
            LCALL           WAIT
            DJNZ            R7,NXTBIT   ; next bit or end of word
; data is only 6 bit, shift two MSB's into address register
            MOV             R7,#2
SHIFT                   MOV             A,R4
            RLC             A               ; shift data
            MOV             R4,A
            MOV             A,R5
            RLC             A               ; shift carry to address
            MOV             R5,A
            DJNZ            R7,SHIFT
            MOV             A,R4            ; shift back data
            RR              A
            RR              A
            MOV             R4,A
; skip the next part if auto repeat is required
CTRL                    MOV             A,R5
; check control bit (bit 5 in address register)
            ANL             A,#20H
            MOV             B,A             ; control bit in B
            XRL             A,R3            ; compare with last value
            MOV             R3,B            ; store control bit
; If the control bit has changed, send new address and data to
; PC, otherwise go to start of program and wait for new code.
            JZ              LOOP

; Send the result to the PC, two subsequent codes separated by
; a SPACE character.
SNDBYT      MOV             A,R5            ; read address + ctrl bit
            ANL             A,#1FH      ; mask three MSB's
            MOV             command,#ccBYTE
            LCALL           MON             ; send byte to PC
            MOV             A,R4            ; read data byte
            LCALL           MON             ; send byte to PC
            MOV             A,#20H      ; ASCII value of SPACE
            MOV             command,#ccCHR
            LCALL           MON             ; send space character
            LJMP            LOOP            ; start again

; Waste some time ((ACC x 4 + 4)µs)
WAIT                    NOP
            NOP
            DJNZ            ACC,WAIT
            RET

            END
934103-12
```

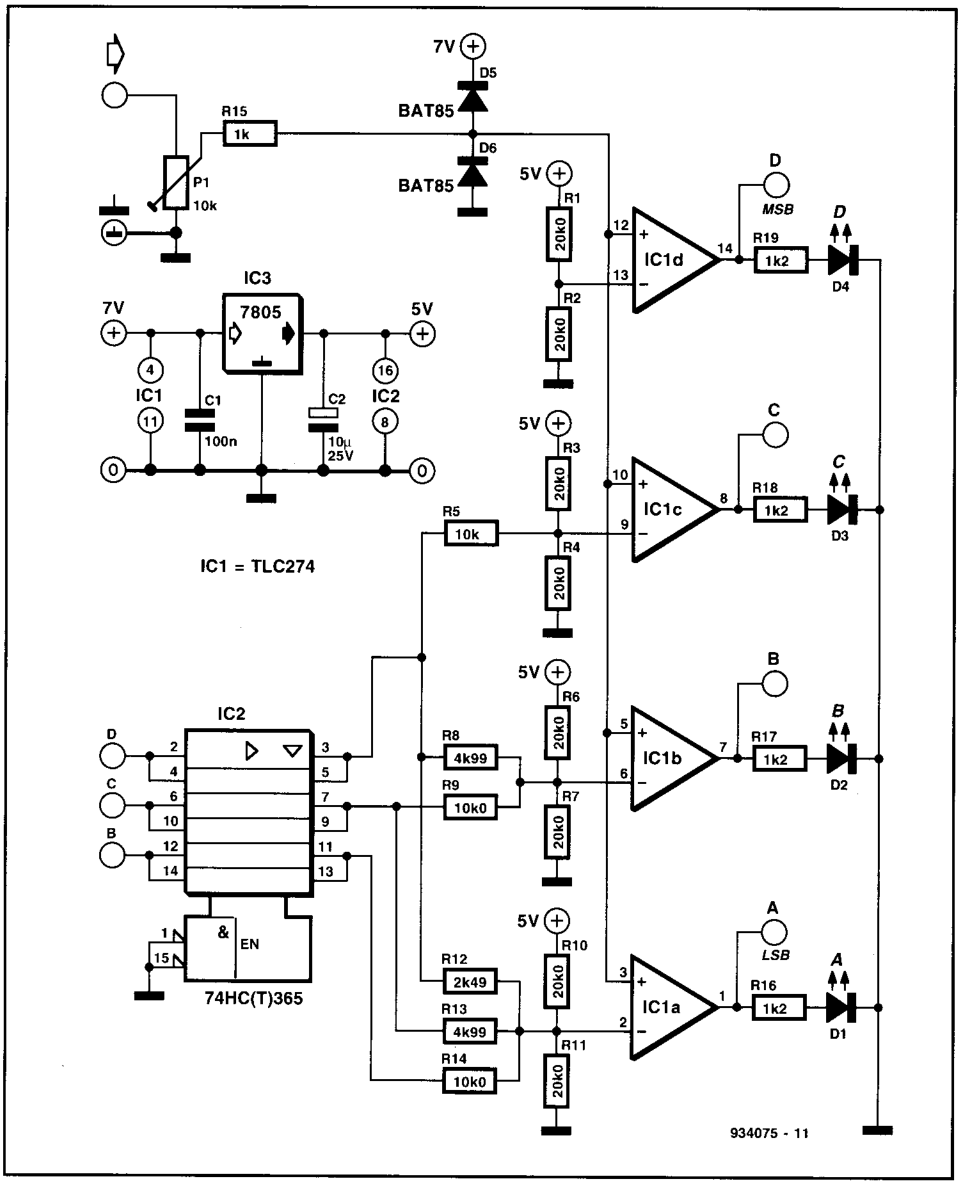
COMPACT A-D CONVERTER

Although good and inexpensive integrated analogue-to-digital (A-D) converters are now readily available, it may be instructive to build one from discrete components.

The present convertor is based on a Type TLC274 IC, which contains four comparators. The outputs of these stages also form the output of the converter.

The problem with designing A-D converters is producing a correctly tracking reference voltage. In fact, each bit requires a small digital-to-analogue (D-A) converter to generate the needed reference. This problem is usually solved by assigning the MSB comparator half the supply voltage as reference: this is produced by potential divider R_1-R_2. For each subsequent bit, the preceding bits are then added to the reference voltage, which requires a few resistors. In case of bit B, this means that bits C and D are used; for bit A, bits B, C and D are used. The translating of the level of these bits is effected by IC_2 and R_1–R_{14}.

The regulated 5-V supply voltage forms the basis for the reference voltage. The levels at the outputs of the buffers should ideally be 5 V (logic 1) or 0 V (logic 0). The resistors in the potential divider should be close tolerance types to ensure good linearity. The higher the resolution (the more bits) of the A-D converter, the more accurate the resistors need to be. It should also be borne in mind that the output level of the buffers in IC_2 deviates more and more from the ideal the greater the current that must be provided. In other words, the value of the resistors must be relatively high. The problem is further minimized by connecting two non-inverting gates in parallel to increase fan-out. With values as shown, the voltage drop at the MSB output buffer (that which provides the largest current) was 6 mV in the prototype. Compared with the value of theLSB of 312.5 mV, this is negligible.



The conversion speed depends on the propagation times of the comparators and buffers. Although the TLC274 performs acceptably, for optimum results true comparators should be used.

The input sensitivity of the circuit is set with P_1.

Diodes D_5 and D_6 protect the opamp inputs against too high potentials.

The current drawn with all LEDs off is about 7 mA; with all four LEDs on, this rises to about 20 mA.

[T. Giesberts - 934075]

BATTERY CHARGING REGULATOR

Philips' IC Type TEA1100 uses the delta-peak principle* to charge NiCd and NiM_3 batteries fast and effectively. The ask of the delta-peak battery charging regulator is to ascertain and evaluate the **change** in the battery voltage: if the voltage at pin 7 drops 1% or more below the average maximum, charging is discontinued. The voltage at pin 7, according to the manufacturers' data sheet, must be 0.385–3.85 V. Potential divider R_4-R_5 ensures that the battery e.m.f. corresponds with this range. The values of these resistors are given by:

$R_4/(R_4+R_5)\cdot n\cdot 1.8 < 3.85;$

$R_4/(R_4+R_5) < 2.14n;$

$R_4/(R_4+R_5)\cdot n\cdot 1.1 > 0.385;$

$R_4/(R_4+R_5) > 0.35n.$

The charging current, I_c, is given by:

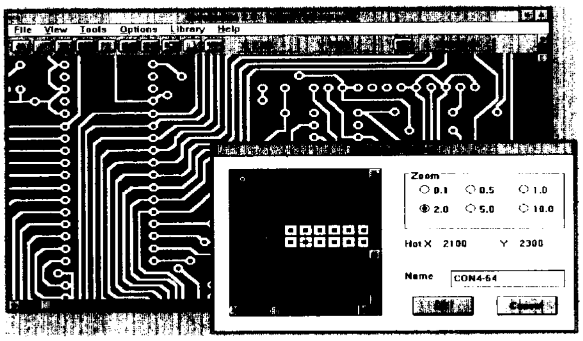
$I_c = 1.25 R_{sense}/R_{shunt}\cdot R_{ref},$

where R_{sense} is R_{10}; R_{shunt} is R_8 in paral-

"... there is no doubt that running under *Windows* puts it ahead of the field and makes it a visually attractive package." Electronics World + Wireless World July 1993

High Quality PCB and Schematic Design for Windows 3/3.1 and DOS

- Supports over 150 printers/plotters including 9 or 24 pin dot-matrix, DeskJet, LaserJet, Postscript, and HPGL. Professional Edition imports GERBER files, and exports GERBER and NC-DRILL files.
- Up to 200,000 pads/track nodes depending on memory. Simple auto-router and schematic capture tools with SPICE compatible net-list output.
- Low cost DOS version (reduced features) also available. Ring for full details!



Hot X 2100 Y 2300

Name CON4-64

"Quickroute provides a comprehensive and effective introduction to PCB design which is a pleasure to use" Radio Communication May 1993.

Quickroute

POWERware, Dept EK, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, UK.
Ring us on 061 449 7101 or write, for a full information pack.

Quickroute is available for Windows 3/3.1 in Professional (£99.00) and Standard (£59.00) editions, and for DOS with reduced features (£39.00). All prices inclusive. Add £5 P+P outside UK.

POWERware Software • Design

from **£39**

lel with R_9; and R_{ref} is R_2.

Timeout, TO, is a safety facility of the IC. If, for whatever reason, no maximum can be detected, the IC stops the charging after the timeout. This time constant is given by

$$TO = 2^{26} \cdot 0.93 \cdot R_{ref} \cdot C_{osc},$$

where $C_{osc} = C_3$. Note that both timeout **and** charging current are influenced by R_2. When the charging current and timeout are being determined, the value of R_2 must therfore be fixed and that of C_3 must be variable.

When the battery is fully charged, the TEA1100 switches to the 'maintain charge' mode. In this mode, during $^1/_{10}$ of the normal charging time $^1/_2$ of the usual charging current flows (in other words, the battery is trickle-charged at $^1/_{20}$ of the normal charging current). This trickle-charge current may be altered on the basis of the following formula:

$$I_{trickle} = 1.25R_{sense} / 10R_{shunt}R_N.$$

The current is determined from the drop across the shunt resistor and switched by the transistors via pin 2 of IC_1.

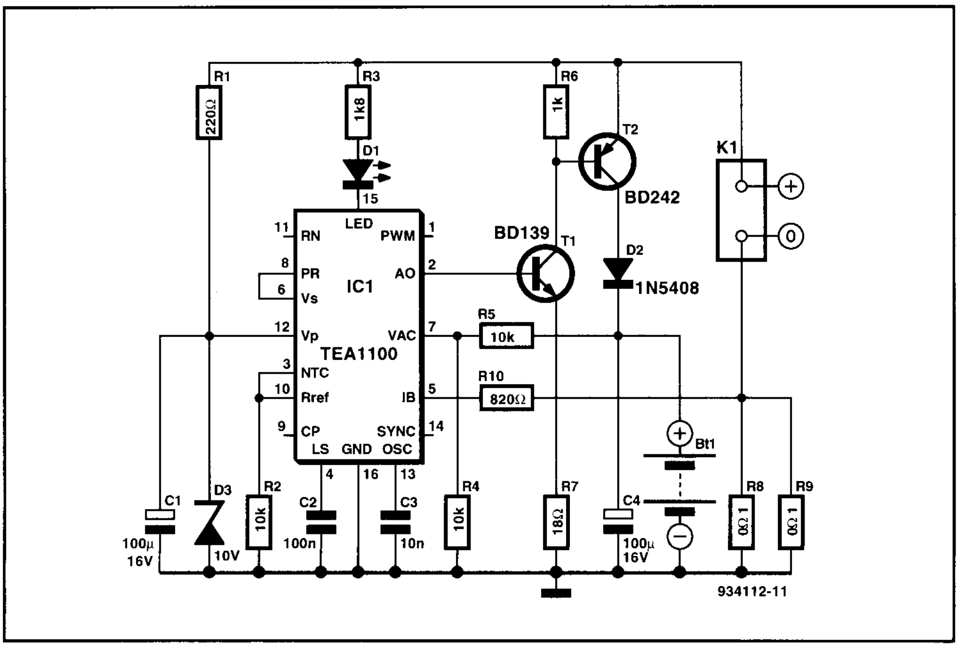
Stability of the circuit is ensured by capacitor C_2.

When no battery is connected to K_1 or when a battery is being trickle-charged, D_1 flashes; when the voltage at pin 7 drops, the LED lights continuously.

The supply voltage at pin 12 must be 5.65–11.5 V. The quiescent current (when the outputs are all off) is some 4 mA.

This IC enables many other applications: a number of these are given in Philips' Data Sheet TEA1100 & TEA1100T.

[A. Rietjens-934112]



The delta-peak principle was described in detail in the December 1992 issue (p. 86) of this magazine.

MULTI-COLOUR-LED

It had to come: an LED that can produce all visible colours. It is the Everlight Type 339-1 VRKGBBW. In fact, it consists of four LEDs in one case: one red, one green, and two blue. When these LEDs are driven into varying brightnesses, all visible colours and white can be produced. The circuit described makes the LEDs light in all colours in any given order.

The circuit consists of an integrator followed by a Schmitt trigger. Together these form an oscillator that produces a triangular voltage with an amplitude of about 1.5 V_{pp} at its pin 1. This signal is applied to one of the LEDs via T_1 and current limiting resistor R_5.

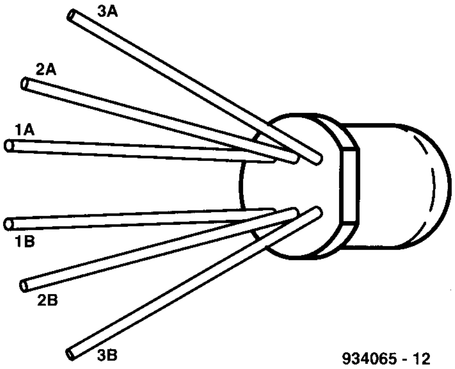
Three of these circuits should be built: one for the red, one for the green, and one for the two blue LEDs. Each circuit should, however, have a different value C_1, say, 470 nF, 330 nF, and 220 nF. Each of the blue LEDs, although connected to the same circuit, should have its own series resistor.

The direct voltage level of the triangular signal may be shifted with P_1. Start with the wiper at earth, and then turn the control very slowly till the LED just begins to light. The best setting is when the LED lights for two thirds of the time and is off for one third.

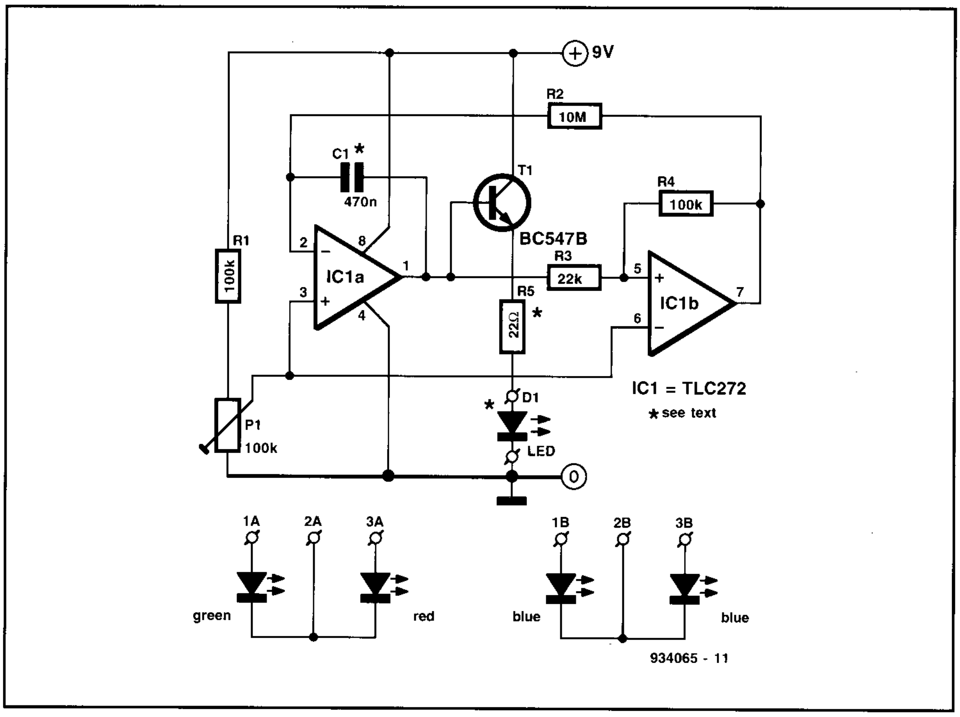
The value of the series resistors is low, because the sensitivity, especially of the blue LEDs, is low.

Do not turn P_1 too far, but take care that the current through the red and green LEDs remains below 30 mA; the blue ones can draw up to 40 mA. The average current drawn by the circuit is then about 70 mA.

[K. Walraven - 934065]



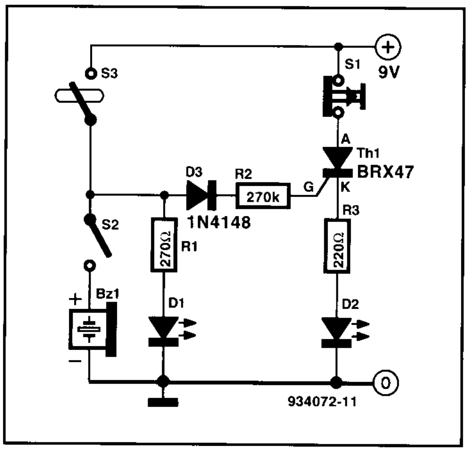
934065 - 12



ANGLER'S BAIT INDICATOR

The indicator shows when a fish has taken the bait. Until that happy moment (at least for the angler), the bite sensor is open, so that both LEDs are out. When a fish has been hooked, the sensor closes the current loop, whereupon both LEDs light. In addition to these diodes, a buzzer may be used to give an audible signal. D_2 continues to light, even when the sensor has been reopened, for as long as the thyristor has no hold current. In this way, each tug on the hook line is indicated by D_1.

The circuit draws a current of 20–60 mA, depending on the type of LED and whether a buzzer is used.



The sensor is made from a mercury switch, cast, half a metre of stranded wire and a 3.5 mm mono jack socket. The cast is placed in the line directly under the reel. When the line is tightened, the indicator is actuated.

[F. Roth - 934072]

Prize Electronic Crossword 2
by Matrix

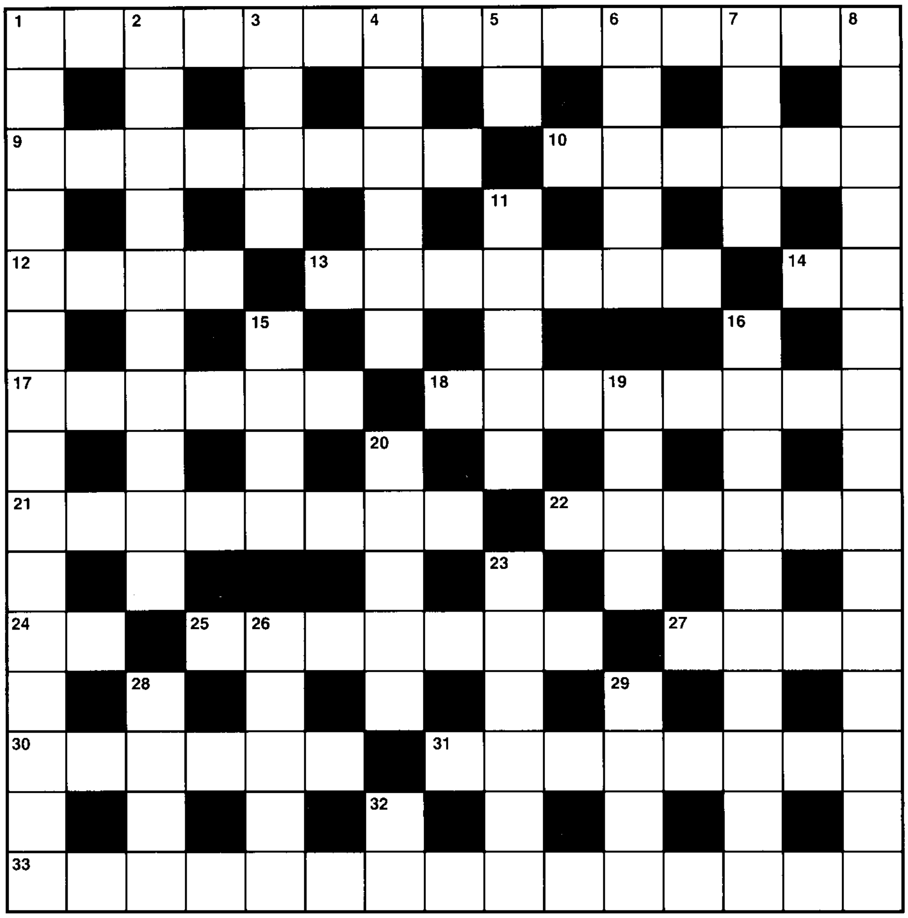
Test your word power in our Christmas crossword competition. Over half the words are used in electronics or in fields in which electronics is important. A knowledge of electronics will, therefore, help you with many of the clues.

Prizes will be given for the first ten solutions opened on Friday, 10 December, 1993. Entries (PHOTOCOPIES NOT ACCEPTED) should be sent to

Prize Electronic Crossword
Elektor Electronics (Publishing)
PO Box 1414, Dorchester
England, DT2 8YH

The winners and solution will appear in our February, 1994 issue (on sale 12 January, 1994)

Prizes for the first five solutions will consist of electronic construction kits: (1st prize up to £30; 2nd prize up to £15; three prizes up to £10). The remaining prizes will consist of Elektor Electronics books



930143 - 11

NAME ....
ADDRESS ....
....
.... POSTCODE ....

Across

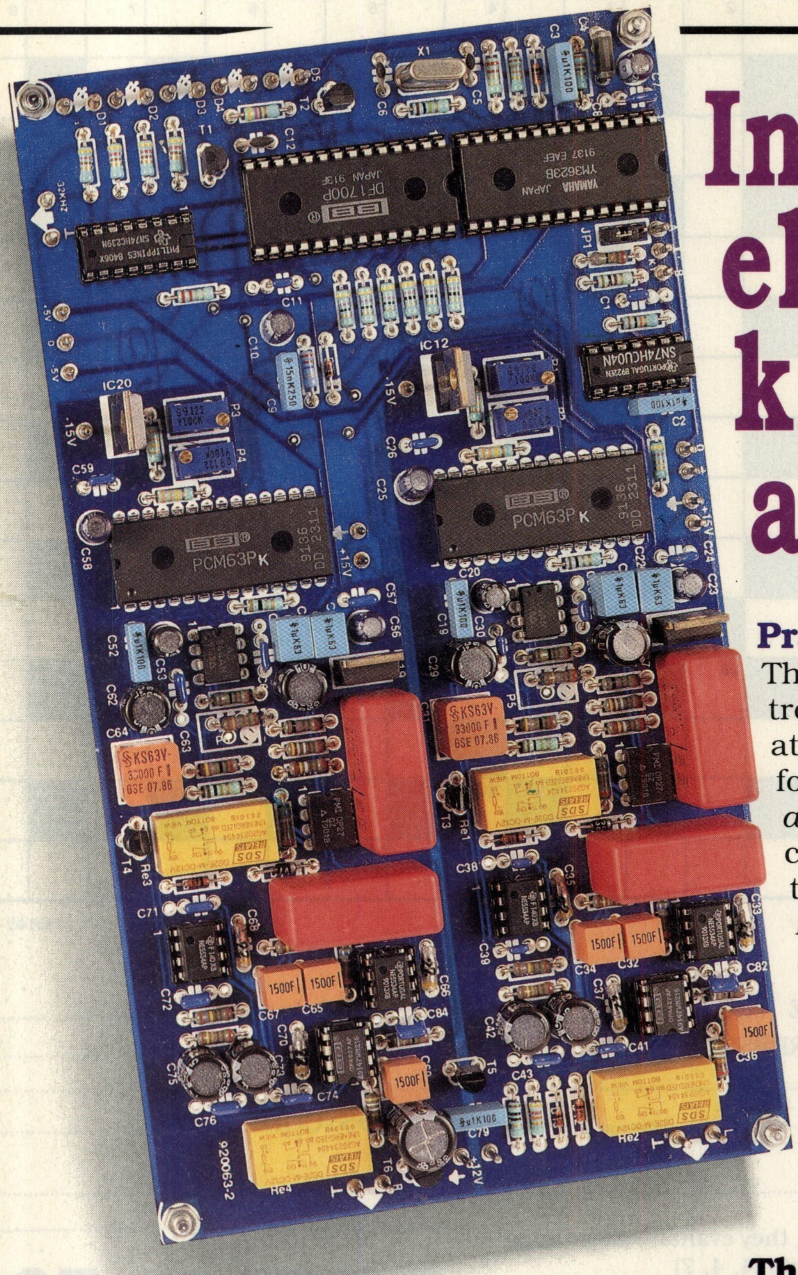
1 Vulgar gatherer has no gain (6, 9)
9 To re-order is paralysed at heart (8)
10 Terse "O", heard on two channels (6)
12 Short-time is cut back, this month (4)
13 A numbered cube is rigid, square (3-4)
14 Classic high-ranker reduces to 26 Down's element (2)
17 Escaping rat is free (6)
18 In a gymkhana, the mare is an accursed thing (8)
21 A sad ending to a valve electrode (8)
22 Ignited Latin mouse is true-blue or red (6)
24 Rapid vibrations terminate a small dense star (2)
25 Sour periods when we are not at our best (3-4)
27 A fawn in the crush (4)
30 Currently, it's a thousand, Ma (6)
31 A great musician begins a first degree (8)
33 Couples in a Durham town achieve high gains (10, 5)

Down

1 The charge made for conveying is CHR$ (8, 7)
2 One-shot is enough for a one-horse town (10)
3 Royal servants express hindrance (4)
4 Hashed and Straight, it puts money in the bank – believe it! (6)
5 Sixth note on the West Coast (2)
6 Reset reset is organic (6)
7 Put this to 3 Down and make billions – Yankees make trillions! (4)
8 Fundamental penny-pinching die-hards, they evaluate alternating currents (4, 4, 7)
11 An Asiatic nomad hidden in a parallel passage (5)
15 Skin flick (4)
16 Little worms passed a tasty dish (10)
19 Barber with a small cap (4)
20 A signal is trapped in this electrode (5)
23 Go-getting person creates potential (6)
26 A cloak of ermine retains maximum energy at absolute zero (5)
28 Blows reversed a boxing match (4)
29 Nick a fragment (4)
32 Light-weight sports car (2)

SAVE £1.50
again and again and again!
Use this coupon to claim a £1.50 discount on THREE tickets to the Computer Shopper Show

2-5 December 1993
Grand Hall, Olympia, London
BLENHEIM
Sponsored by Computer Shopper Magazine
Show opening times
Thursday 2 - Saturday 4 December 10.00am - 6pm
Sunday 5 December 10.00am - 5pm
Photocopies not valid. Valid on entry to show only.



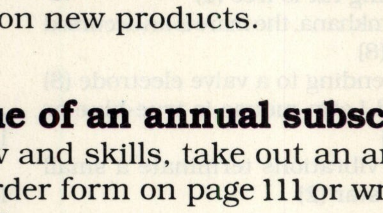
Increase your electronics know-how and skills

Practical creativity in electronics

The speed and intensity with which electronics penetrates our daily lives at home, at work, or in our car, tends to make us forget that we *can use electronics creatively* by building designs with a practical application and having the satisfaction of a successfully finished project. *Elektor Electronics*, which is distributed all over the world, can help you achieve these goals. Throughout the year, the magazine features original construction projects, informative articles and news on the gamut of electronics, science & technology, book reviews and information on new products.

The value of an annual subscription

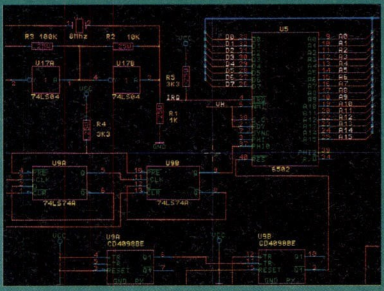
If *you* wish to increase your electronics know-how and skills, take out an annual subscription to *Elektor Electronics* by filling in the order form on page 111 or writing or telephoning to the address below. You will then not only have the convenience of having the magazine delivered to your home and the peace of mind that you will not miss any issue, but you will also save money compared with buying the magazine from a bookstall: the price of a subscription in Britain for the 11 annually published issues is the same as the average price of 10 issues bought from a bookstall. Rates are shown on page 112.



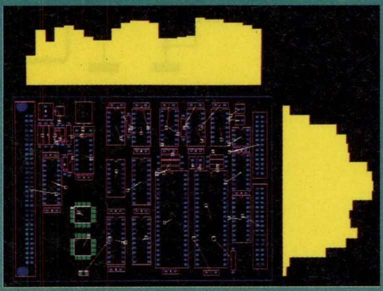
World Wide Subscription Service Ltd,
Unit 4, Gibbs Reed Farm,
Pashley Road, TICEHURST,
East Sussex TN5 7HE, England
Telephone (0580) 200 657 (*National*)
or +44 580 200 657 (*International*)
Fax (0580) 200 616 (*National*)
or +44 580 200 616 (*International*)

ELEKTOR ELECTRONICS

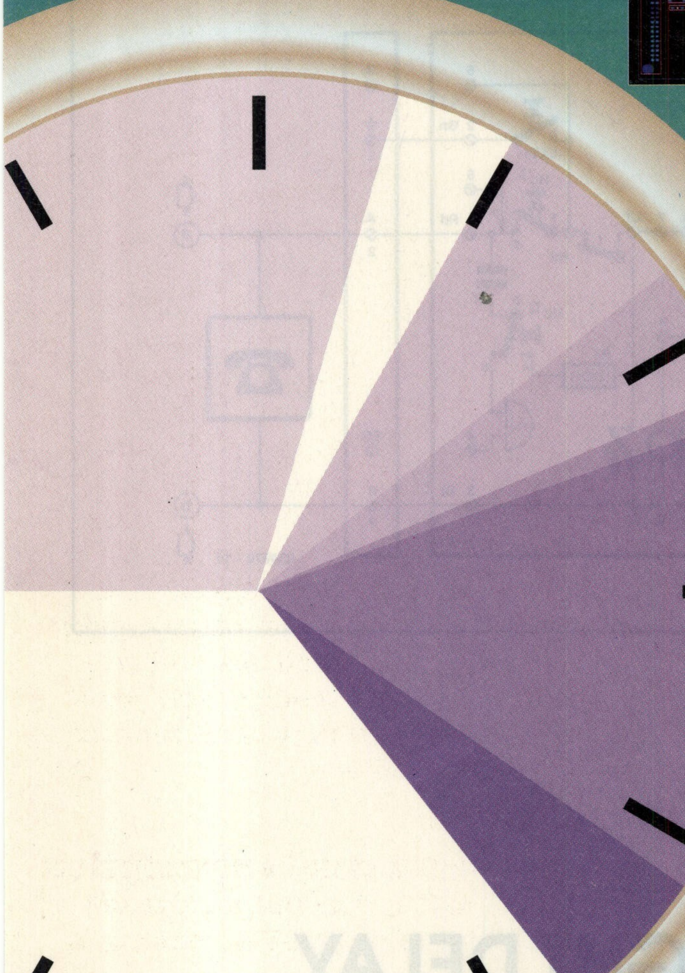
FROM CONCEPT TO ARTWORK IN 1 DAY

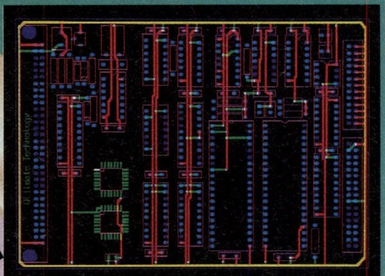


Your design ideas are quickly captured using the ULTIcap schematic design Tool. ULTIcap uses REAL-TIME checks to prevent logic errors. Schematic editing is painless; simply click your start and end points and ULTIcap automatically wires them for you. ULTIcap's auto snap to pin and auto junction features ensure your netlist is complete, thereby relieving you of tedious netlist checking.

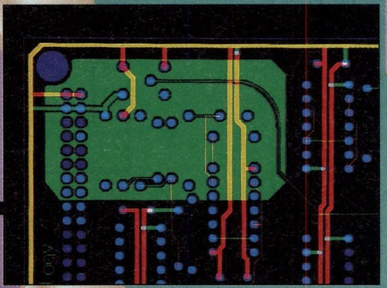


ULTIshell, the integrated user interface, makes sure all your design information is transferred correctly from ULTIcap to ULTIboard. Good manual placement tools are vital to the progress of your design, therefore ULTIboard gives you a powerful suite of REAL-TIME functions such as, FORCE VECTORS, RATS NEST RECONNECT and DENSITY HISTOGRAMS. Pin and gate swapping allows you to further optimise your layout.

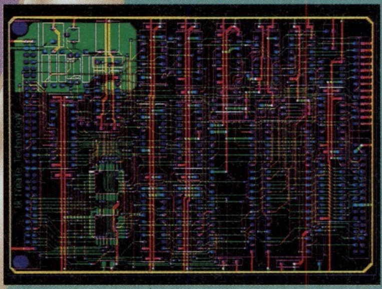




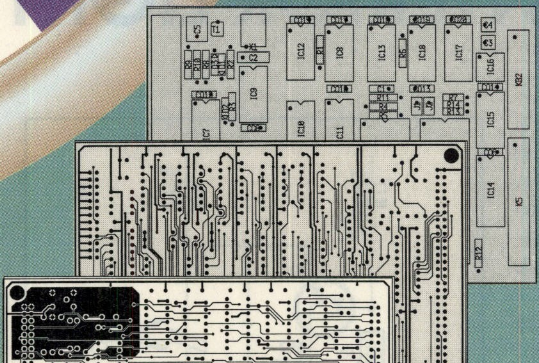
Now you can quickly route your critical tracks. ULTIboard's REAL-TIME DESIGN RULE CHECK will not allow you to make illegal connections or violate your design rules. ULTIboard's powerful TRACE SHOVE, and REROUTE-WHILE-MOVE algorithms guarantee that any manual track editing is flawless. Blind and buried vias and surface mount designs are fully supported.



If you need partial ground planes, then with the Dos extended board systems you can automatically create copper polygons simply by drawing the outline. The polygon is then filled with copper of the desired net, all correct pins are connected to the polygon with thermal relief connections and user defined gaps are respected around all other pads and tracks.



ULTIboard's autorouter allows you to control which parts of your board are autorouted, either selected nets, or a component, or a window of the board, or the whole board. ULTIboard's intelligent router uses copper sharing techniques to minimise route lengths. Automatic via minimisation reduces the number of vias to decrease production costs. The autorouter will handle up to 32 layers, as well as single sided routing.



ULTIboard's backannotation automatically updates your ULTIcap schematic with any pin and gate swaps or component renumbering. Finally, your design is post processed to generate pen / photo plots, dot matrix/laser or postscript prints and custom drill files.

NEW

ULTIboard/ULTIcap evaluation system:
- **all** features of the bigger versions
- full set of manuals
- design capacity 350 pins

Price incl. S & H, excl. VAT: **£ 75**

Purchase price is 100% credited when upgrading to a bigger version. • *Also suitable for study & hobby*

ULTIboard PCB Design/ULTIcap Schematic Design Systems are available in low-cost DOS versions, fully compatible with and upgradable to the 16 and 32 bit DOS-extended and UNIX versions, featuring unlimited design capacity.

The European quality alternative

ULTICAP + ULTIBOARD = MAXIMUM PRODUCTIVITY

ULTImate Technology UK Ltd. • 2 Bacchus House, Calleva Park, Aldermaston Berkshire RG7 4QW • Fax: 0734 - 815323 • Phone: 0734 - 812030

TELEPHONE MONITOR

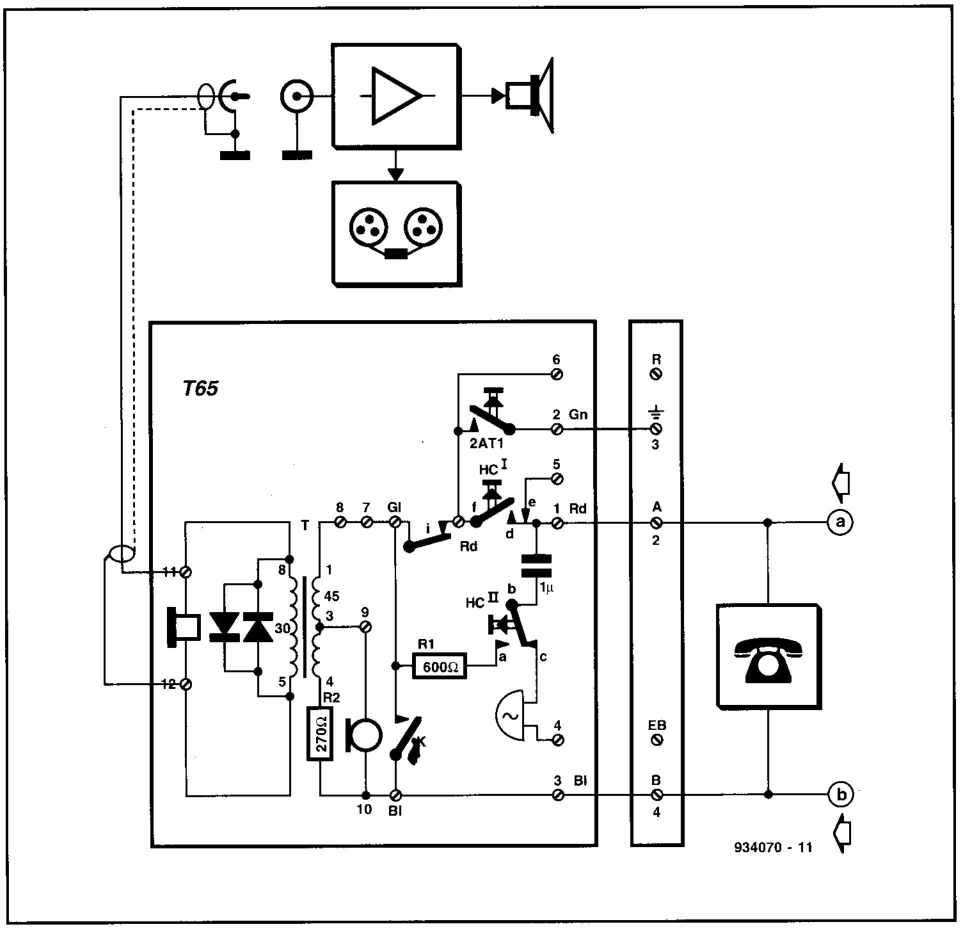
It is sometimes necessary to make a telephone conversation audible to more than one person at either end or to make a tape recording of it (as in many businesses). Often, this is done with the aid of a microphone fitted with a suction cup. This does not work very well, though, whence the present circuit.

Use an old, but still serviceable, telephone set connected across the telephone line in parallel with the receiver to be monitored. Connect a length of screened audio cable across the receiver inset and to an amplifier or tape recorder, as the case may be. As soon as a conversation has to be recorded or amplified, take the receiver from the hook and adjust the input level of the amplifier or recorder as required. Do not set the amplifier gain too high, because this may give rise to howling.

The hook contact of the additional telephone set prevents the bell voltage (50 V or more) reaching the audio equipment. Furthermore, the audio equipment is electrically isolated from the telephone line by the 1:1 telephone transformer, T.

In most west European countries it is now allowed for telephone sets to be connected in parallel, in spite of the resulting paucity of the signal quality (primarily caused by the reduced echo attenuation).

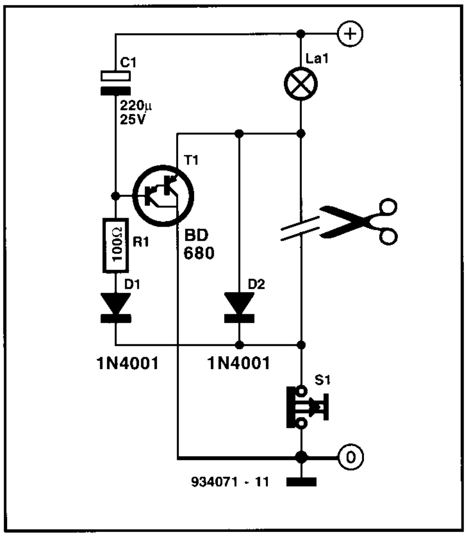
[L. Lemmens - 934070]



CAR INTERIOR LIGHT DELAY

The delay circuit ensures that a car's interior light remains on for about five seconds after all the doors have been closed. This enables the ignition lock to be found easily in the dark (many modern cars have an illuminated ignition lock as standard).

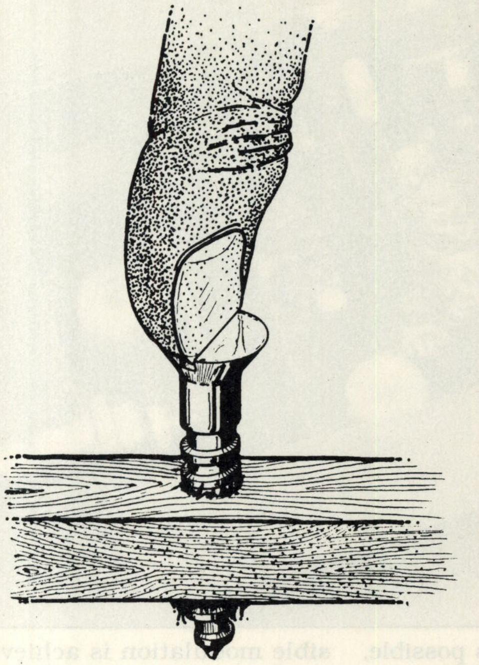
When one of the front doors of the car is opened, the door switch (here, S_1) closes. A current will then flow through interior light L_1 via S_1 and D_2. At the same time, capacitor C_1 is charged rapidly via R_1, D_1 and S_1. When the door is closed, S_1 opens. At the same instant, T_1 is switched on by the low level at the –ve terminal of C_1. After a little while, depending on the value of C_1 and the base current of T_1, the base voltage of T_1 has risen to a level where the transistor ceases to conduct, so that L_1 goes out.



[A. Rietjens - 934071]

Note. In quite a few modern cars, the circuit described (or one like it) is a standard fitting. [Editor]

8051 Programming?



If you've tried this, you'll know what it's like using 8051 assembler.

Admittedly, given enough time and effort, even the impossible can be accomplished.

But can your project afford to wait?

Keil C51 is ***very*** simple to use and yet yields the fastest and smallest code of any 8051 C compiler. With direct access to the 8051 cpu at a bit/register level in C, assembler programmers feel instantly at home.

C51 Professional Developer's Kit *Comprises:*

- *Full ANSI C implementation for the 8051 family*
- *Near-assembler code efficiency*
- *Function-level optimisation*
- *Extensions for 80C517/80C751*
- *Small/Compact/Large/Banked memory support*
- ***DScope51+** cpu simulator/debugger*
- ***A51** macro assembler*
- *8051 Real Time Executive*
- *Support from official **C51 User Group***
- *Free 8051 C Programmer's Handbook*

To see how **C51** takes the pain out of 8051 programming, call now for our comprehensive information pack including demonstration versions of the compiler and debugger.

Hitex (UK) Ltd
Warwick University
Science Park
Coventry, CV4 7EZ

hitex

KEIL ELEKTRONIK

☎ 0203 692066, FAX 0203 692131

Baylin Publications

ALL ITEMS EX-STOCK.

Ku Band Satellite TV, Theory, Installation & Repair 4th Edition. Footprints, dish theory, cables, site survey, polar mount adjustment. ***£25.***

24 River Gardens,
Purley, Reading.
RG8 8BX. England.
Tel/Fax 0734-414468
Mobile 0836-582785
Pay by: UK£ cheque, Access, Mastercard, Visa, C.O.D.

European Scrambling Systems, Circuits, Tactics & Techniques. By John McCormac, digital sound, smart cards, pirate decoders, for hackers. ***£32.***

World Satellite TV & Scrambling Methods. 2nd Edition, by Baylin, Madox & McCormac for the service engineer. ***£29.***

Home Satellite TV Installation Videotape. Forty minutes VHS Pal. See how 3 metre dishes are installed. ***£27.***

Satellite Installation Guide. 3rd Edition. By John Breeds. ***£13.***

The Satellite Book. 2nd Edition. A complete guide to satellite TV . Theory and practice by John Breeds. ***£31.***

World Satellite Almanac. 3rd Edition by Mark Long. 300 Footprints, Frequencies, Transponder Loading, Orbital Assignments. ***£69.***

World Satellite Annual. Update by Mark Long. ***£39.***

TVRO System Analysis and Aiming Software. 5.25 or 3.5 disk, (DOS 3.2). Calculates dish size and lists coordinates of all satellites in view. ***£39.***

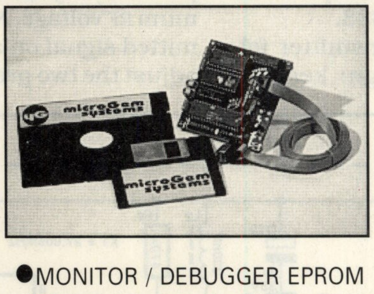
Satellite Toolbox Software, for IBM Comp. Hard Disk– 5.25 or 3.5. ***£59.***

Wireless, Cable & SMATV, Microwave broadcasting & cable TV. ***£35.***

World Satellite Yearly by Dr. Baylin, Loading and 200 Footprints. ***£38.***

PRICES INCLUDE P. & P. UK. Airmail Europe add 10%. Outside Europe +20%.

ULTRA LOW COST 8051 DEVELOPMENT SYSTEM



MG51EV
EVALUATION BOARD
BUILT & TESTED

£39
+VAT + P&P

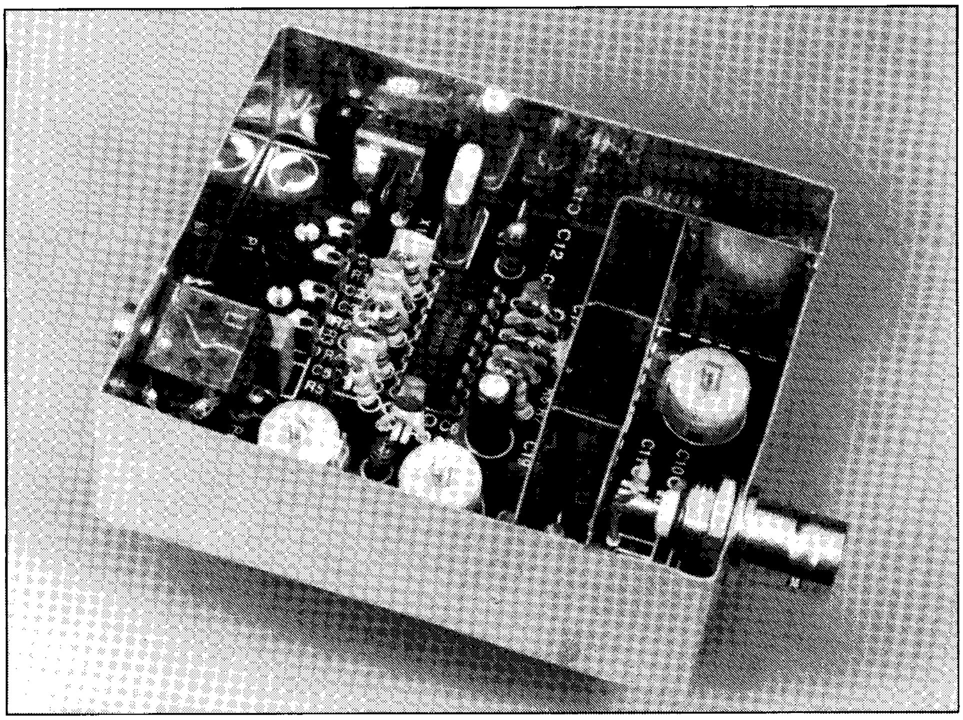
●MONITOR / DEBUGGER EPROM
all debug commands: Dump, Enter, Fill, Go, Move, Register...
ASSEMBLE & UNASSEMBLE functions....
full access to ROM, internal and external RAM areas
●8kbytes RAM for prog./data (Extendable upto 32kbytes)
●16 I/O LINES (including the serial port, timers, interrupts)
●DOWNLOAD INTEL HEX FILES
●HW/SW RESET
●AUTOMATIC BAUD-RATE ADJUSTING (600, ... 4800 baud)
●TERMINAL PROGRAM & USER'S MANUAL
supplied on 5.25" or 3.5" disks for IBM PC compatibles
●SERIAL COMMUNICATION CABLE for IBM PC compatibles
●FULL TECHNICAL SUPPORT

CALL US NOW ON 081-656 96 43

μG **microGem systems**
COMPUTER BASED SYSTEMS
DESIGN & CONSULTANCY

112 LONGHEATH
GRDNS
ADDISCOMBE
CROYDON
SURREY
CR0 7TP

LOW POWER NBFM TRANSMITTER



The transmitters is a crystal-controlled, battery-powered, one-chip narrowband FM (NBFM) model for operation in the 27-MHz band, primarily as a wireless microphone*.

The circuit is an application of Motorola's MC2833 single-chip VHF narrowband FM transmitter IC, designed to work in the 27-MHz band. The transmitter output power is about 10 mW (+10 dBm), which, owing to the expected low efficiency of the antenna used, will result in a typical effective radiated power (ERP) of less than 1 mW. The range of the transmitter, therefore, is limited to 10–20 metres (33–66 ft).

The active circuitry contained in the MC2833 includes a microphone amplifier, a voltage controlled oscillator, and two auxiliary transistors which are used for frequency multiplication or RF amplification, depending on the desired output frequency.

Preset P_1 is used to adjust the microphone gain, and preset P_2 to adjust the deviation. Remember, the transmitter will produce NBFM only, with a maximum deviation of 5 kHz. This means that a narrow-band receiver (such as a typical 27 MHz CB unit) is required for sufficient audio output.

The quartz crystal, X_1, resonates in fundamental mode (here, 9 MHz), calibrated for parallel resonance with a 32 pF load. The final output frequency is generated by frequency multiplication (here, ×3) within the MC2833.

Construction of the transmitter follows the rules of RF design: keep all component leads as short as possible, fit the screening as indicated on the printed circuit board, and do not use an IC socket for IC_1.

The transmitter is fairly simple to adjust: simply peak the three trimmers, C_8, C_9 and C_{18}, for maximum output power delivered to a 50 Ω dummy load. Alternatively, connect the antenna and an oscilloscope to the transmitter output, and adjust the trimmers for maximum RF voltage. Next, listen to the transmitted signal on a 27 MHz receiver, and adjust the two presets until the best possible modulation is achieved. Do not set the microphone gain too high, since this will easily cause clipping.

If the transmitter is used as a wireless microphone, the antenna will typically be a piece of flexible wire with a length of about 1 m. The transmitter draws a current of about 7 mA, so it is good practice to keep an eye on the state of the battery.

(J. Barendrecht — 914114)

* This transmitter is not licensable as a wireless microphone in the UK.

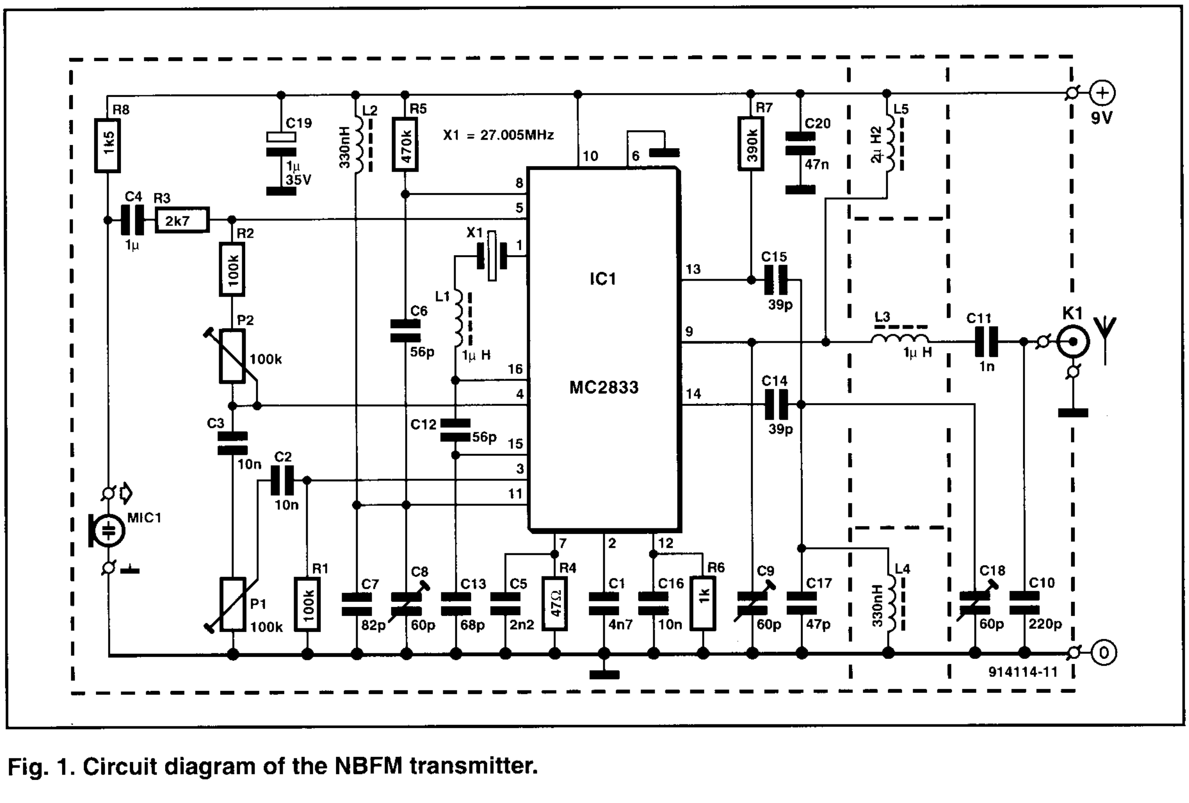


Fig. 1. Circuit diagram of the NBFM transmitter.

PARTS LIST

Resistors:
R_1, R_2 = 100 kΩ
R_3 = 2.7 kΩ
R_4 = 47 Ω
R_5 = 470 kΩ
R_6 = 1 kΩ
R_7 = 390 kΩ
R_8 = 1.5 kΩ
P_1, P_2 = 100 kΩ preset, H

Capacitors:
All fixed capacitors are ceramic, unless otherwise indicated
C_1 = 4.7 nF
C_2, C_3, C_{16} = 10 nF
C_4 = 1 μF MKT
C_5 = 2.2 nF
C_6, C_{12} = 56 pF
C_7 = 82 pF
C_8, C_9, C_{18} = 60 pF foil trimmer
C_{10} = 220 pF
C_{11} = 1 nF
C_{14}, C_{15} = 39 pF
C_{17} = 47 pF
C_{19} = 1 μF, tantalum
C_{20} = 47 nF

Inductors:
L_1, L_2 = 1 μH
L_3, L_4 = 330 nH
L_5 = 2.2 μH

Integrated circuits:
IC_1 = MC2833P (Motorola)

Miscellaneous:
K_1 = BNC socket
X_1 = crystal, 27.005 MHz
MIC_1 = Electret microphone

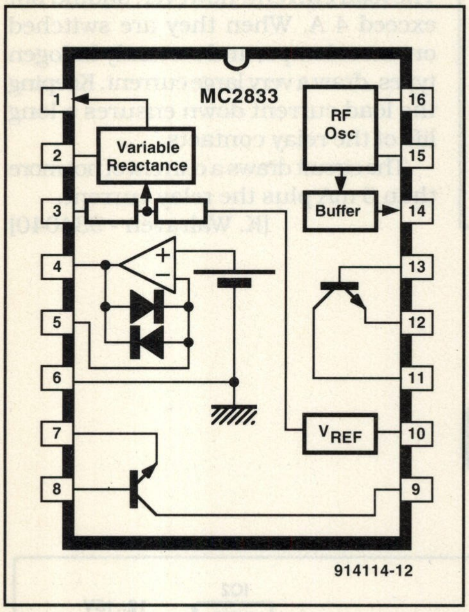


Fig. 2. Block diagram of the MC2833P

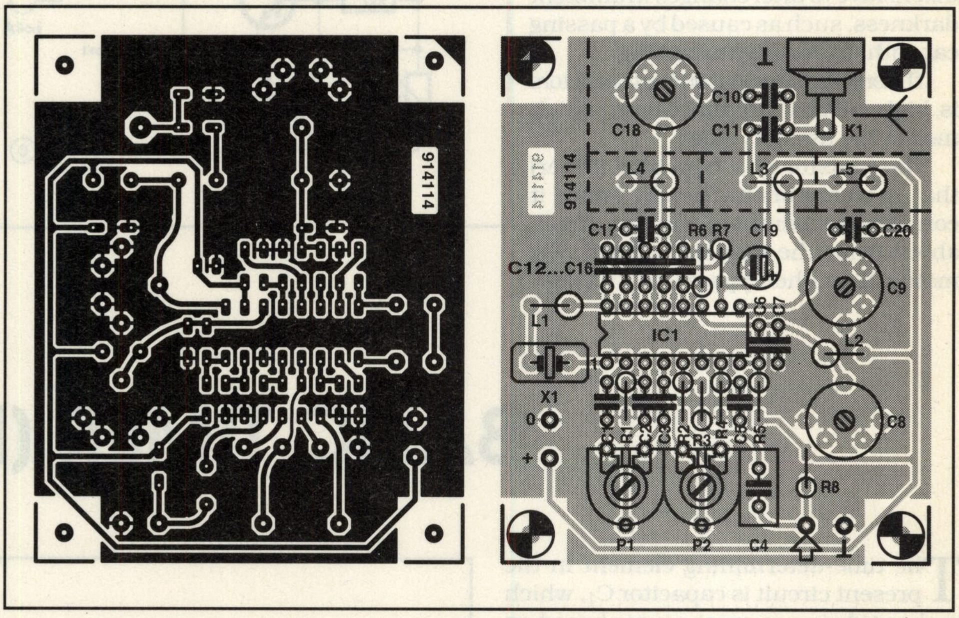
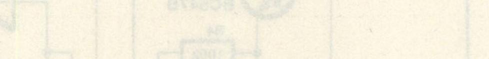


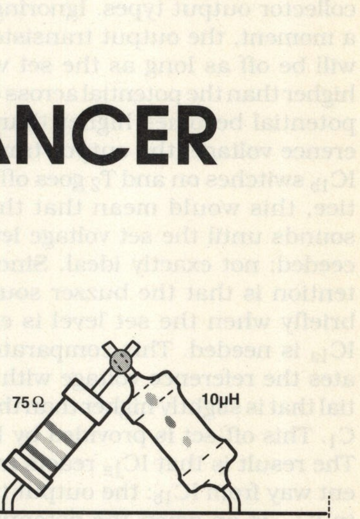
Fig. 3. The printed circuit for the NBFM transmitter (not available ready made).

INEXPENSIVE VIDEO ENHANCER

Often, a video signal applied to the TV receiver via the SCART or AV input appears rather less well-defined than a signal applied directly from the antenna socket. A considerable improvement may be ontained by connecting an inductor of about 10 μH in series with the input resistor of the SCART or AV socket (this resistor is normally 75 Ω or 82 Ω). The inductor raises the input impedance at higher frequencies, so that these are attenuated less than the lower frequencies. The improvement is particularly noticeable with signals of limited bandwidth (such as from a video cassette recorder): the picture is sharper and the colours are fuller.

[J. Bodewest - 934120]





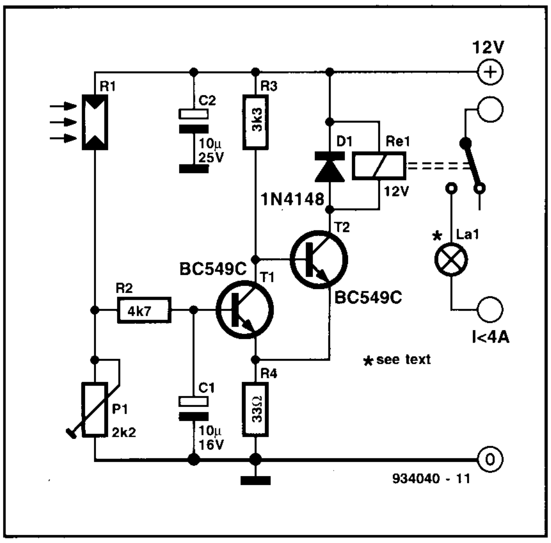
AUTOMATIC TWILIGHT SWITCH

This is one of the simplest twilight switches ever published in this magazine. When it gets dark, the value of light-sensitive resistor R_1 increases, whereupon T_1 switches off. Transistor T_2 then switches on and this energizes relay Re_1. At the same time a voltage drop of about 1 V develops across R_4: this is the hysteresis of the switch.

Capacitor C_1 serves to make the switch insensitive to brief changes in ambient darkness, such as caused by a passing car with its headlights blazing.

The only requirement on the transistors is high current amplification, which means the use of C types.

The varistor is a new type (Piher) that is environment-friendly (since it contains no cadmium) and very small: about twice the size of the head of a match. If another type is used, its daylight resistance should be of the order of a few hundred ohms; this should increase to about 10 kΩ at twilight. In any case, the value of P_1 may be increased (within reason).



During calibration, unsolder C_1 from earth: the circuit then reacts faster.

The relay should be a 12 V type that needs an energizing current ≤50 mA.; its contact should be able to switch 8 A. The load current, however, should not exceed 4 A. When they are switched on, most lamps, and certainly halogen types, draw a very large current. Keeping the load current down ensures a long life of the relay contacts.

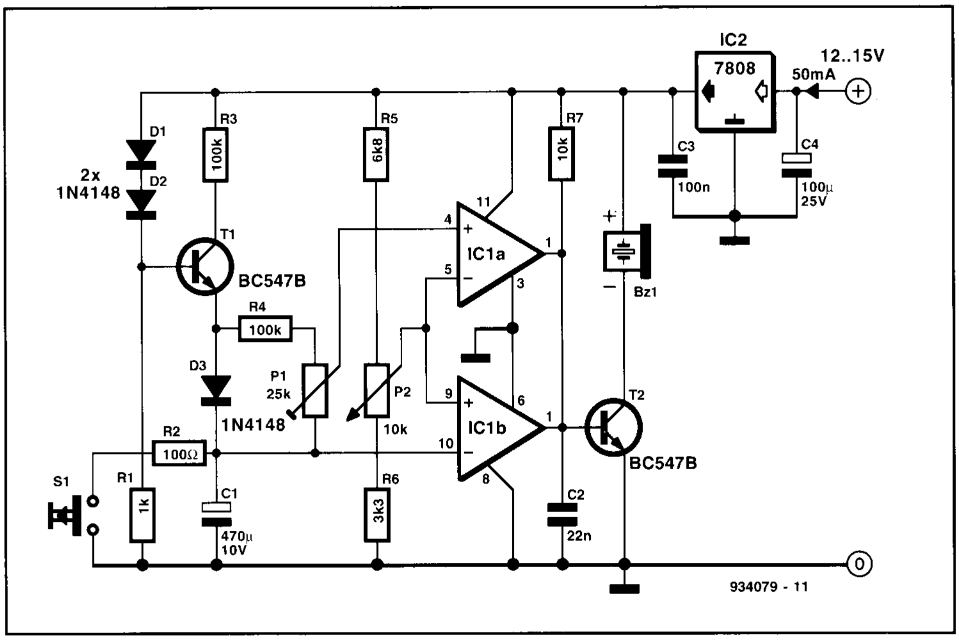
The circuit draws a current of not more than 5 mA plus the relay current.

[K. Walraven - 934040]

BASIC TIMER (I)

The time-determining element in the present circuit is capacitor C_1, which is charged via a current source based on T_1. The voltage across the capacitor is, therefore, a ramp. A comparison of this ramp with a preset voltage gives a fairly accurate time indication. With values shown in the present circuit, that time lies between 1 and 10 minutes.

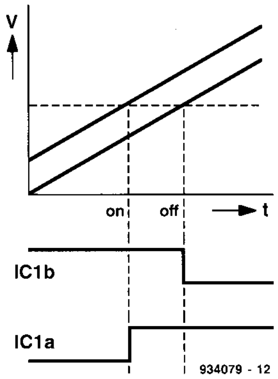
The ramp and reference voltage are compared by IC_{1a} and IC_{1b}, both open-collector output types. Ignoring IC_{1a} for a moment, the output transistor of IC_{1b} will be off as long as the set voltage is higher than the potential across C_1. If that potential becomes higher than the reference voltage, the output transistor in IC_{1b} switches on and T_2 goes off. In practice, this would mean that the buzzer sounds until the set voltage level is exceeded: not exactly ideal. Since the intention is that the buzzer sounds only briefly when the set level is exceeded, IC_{1a} is needed. This comparator evaluates the reference voltage with a potential that is slightly higher than that across C_1. This off-set is provided by R_4-P_1-D_3. The result is that IC_{1a} reacts in a different way from IC_{1b}: the output transistor in IC_{1a} is on when the potential across C_1 plus that at the wiper of P_1 is lower than the reference voltage, and is switched off when the reference voltage is exceeded. Thus, this comparator starts the buzzer sounding for an infinitely long period just before the set time has elapsed.



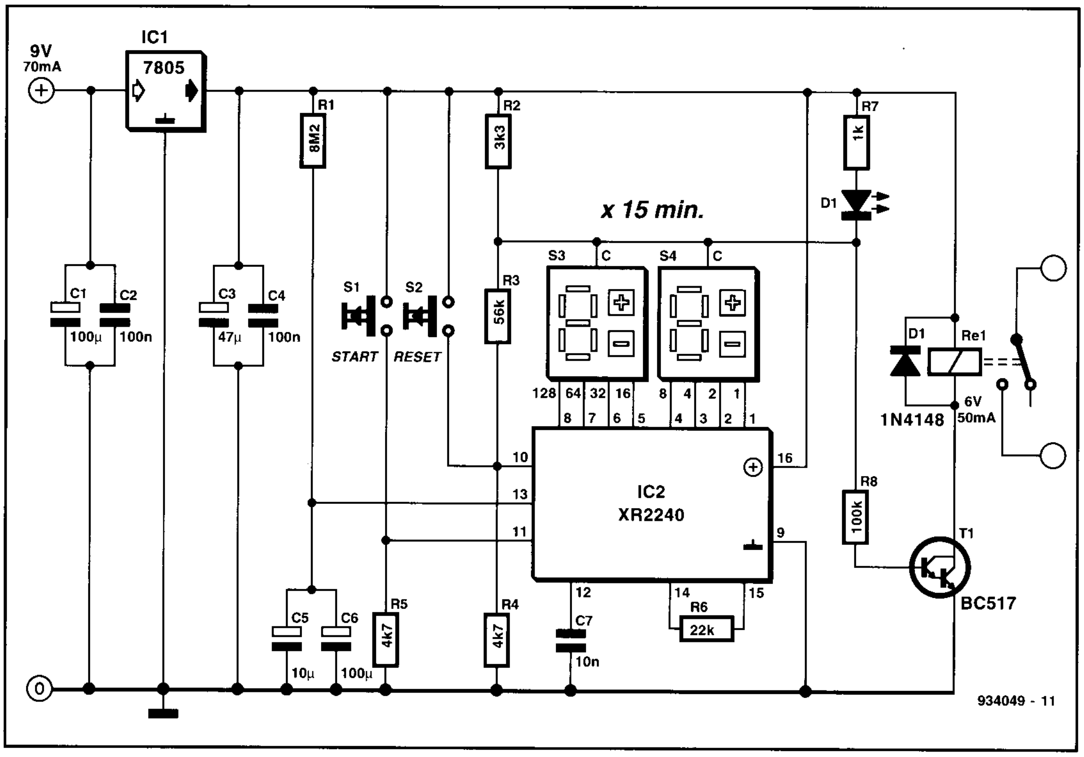
Summing up the action: one output actuates the buzzer after a certain period of time has elapsed, while the other output switches the buzzer off again after a slightly longer period of time has elapsed. Thus, the buzzer sounds only during the short overlap of these two periods. The length of this overlap is set with P_1. The time period before the buzzer is actuated is set with P_2.

The timer is started when S_1 is pressed.

[A. Rietjens - 934079]



LONG-DURATION TIMER



The timer, based on EXAR's Type XR2240, is intended for use in photographic and printed-circuit departments, as a standby switch for TV and radio equipment, as a battery charging monitor, and similar applications. The timing can be set between 15 minutes and 24 hours 45 minutes with two BCD (binary coded decimal) switches.

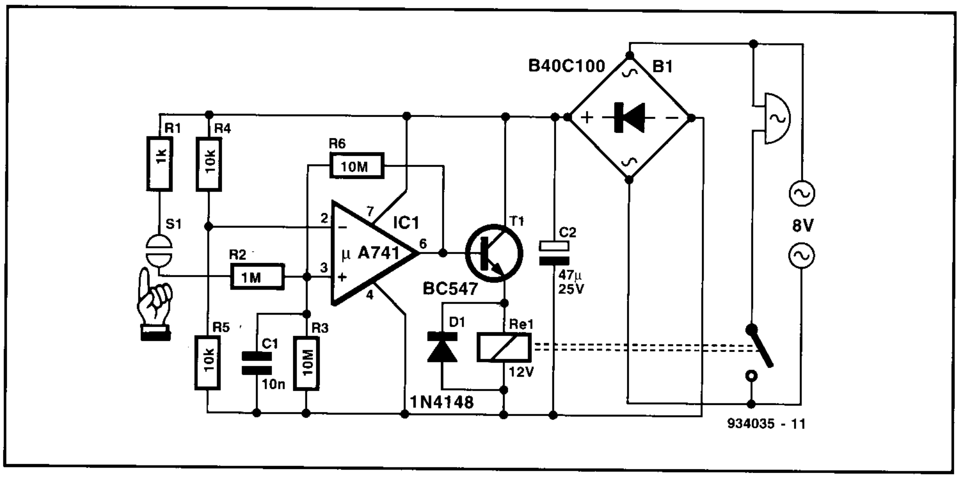
The timing is programmed in steps, *T*, which are determined by the time constant $R_1(C_5 + C_6) = 15$ minutes. The BCD switches allow up to 255 such periods to be selected. The timer functions are controlled by an internal bistable (flip-flop) and switches S_1 and S_2. To keep the period accurate, C_5 and C_6 must be carefully selected.

Diode D_1 lights when the timer is switched on. The voltage at junction D_1-R_2-R_3-R_8 is then so low that T_1 remains off. When the set time has elapsed, pin 10 of IC_2 becomes logic high, whereupon the supply voltage exists at the junction. The LED then goes out, T_1 conducts and relay Re_1 is energized, so that its contact changes over.

The supply voltage to the timer is stabilized by regulator IC_1. Capacitors C_1–C_4 smooth the supply voltage to prevent the timer being triggered by pulses on this voltage.

[G. Geißler - 934049]

ELECTRONIC BELL-PUSH



A solid-state bell-push is far more robust than the usual mechanical type. The touch contact may be made from an audio socket, which has a high insulation resistance and is practically indestructible.

The inverting (–) input of IC_1 is at half the supply voltage via R_4-R_5, while the non-inverting input is at earth potential via R_3. When the contact is touched (less than 10 MΩ, a light touch is fine), the output of the opamp goes high and the relay (a 9-V or 12-V type) is energized. The relay contact then actuates the (existing) bell. Resistor R_1 and capacitor C_1 ensure that the bell cannot be actuated accidentally.

The circuit is powered by the rectified bell transformer voltage (or a second bell transformer – for safety's sake, do not use a different type of transformer). A bell transformer can normally provide a current of 1 A, so the first solution is almost always possible.

The circuit draws a (quiescent) current of only 5 mA if a 741 is used and only 0.5 mA if a TLC271 is used. When the relay is energized, this rises by 30 mA.

[J. Bosman - 934035]

COMING SOON TO A FRONT ROOM NEAR YOU...
THE NEW MILLEN-NIUM 4-20 AMPLIFIER
Millennium 4-20
IT'S NOT A DINOSAUR!

FOR TIMELESS QUALITY VALVE SOUND — AT AN AFFORDABLE PRICE!

Look out for the January and February 1994 issues of *Electronics — The Maplin Magazine* for detailed instructions of how to build this superb amplifier yourself!

UK Readers: *Electronics — The Maplin Magazine* is available from **Maplin Stores** nationwide, **WHSMITH, Martin the newsagent, R S McColl,** other leading news stockists and by subscription. For details phone, fax or write to: Subscriptions Dept., Maplin Electronics PLC, P.O. Box 3, Rayleigh, Essex SS6 8LR. Tel: (0702) 554161. Fax: (0702) 553935. UK subscription rate for 12 issues: £19.92.

Overseas Readers: *Electronics — The Maplin Magazine* (listed in the International Press Directory) can be obtained from your local news stockist and by subscription. For details phone, fax or write to: Overseas Subscriptions Dept., Maplin Electronics PLC, P.O. Box 3, Rayleigh, Essex SS6 8LR, England. Tel: +44 702 554155 extension 326 or 351. Fax: +44 702 553935. Subscription rates for 12 issues in pounds sterling: Air Mail (Europe) £29.00; Surface Mail (Outside Europe) £29.00; Air Mail (Outside Europe) £41.00.

South African Readers: *Electronics — The Maplin Magazine* is available from Maplin South Africa and by subscription. For details phone, fax or write to: Subscriptions Dept., Maplin South Africa (Pty.) Ltd., P.O. Box 1846, Somerset West 7129, South Africa. Tel: (024) 51 5124. Fax: (024) 51 2507.

KITS AND COMPONENTS FOR *Elektor Electronics* PROJECTS

December 1993

prices in NLG (Netherlands guilders)

I^2C power switch

PCF8574A	9.50
PCB mount 6-way mini-DIN socket	2.85
S201S02 SSR	9.85

80C535 card with EPROM emulator

Kit, incl. LCD, PCB, GAL and PAL, 80C535 datasheet, IC sockets **.338.00**

P&P 12.50 (Europe)

P&P 20.00 (outside Europe)

Individual parts:

LCD LM016A21 2x16 char.	59.00
SAB80C535L	32.50
62256-100L	11.00
MAX232N	5.95
74LS574	2.45
PLCC 68 socket	4.75
96-way a-c row connector	6.50
SAB80C535 datasheet	9.75

Telephone-controlled switch (1-94)

B40C1500	4.00
80C31	21.50
CNY65	4.65
MV8870	18.50
V23037-A2-A101	9.50
VLL3715T line transformer	41.00
3.579 MHz crystal	4.10
12 MHz crystal	4.10
SK129/25.4 heatsink	5.35

November 1993

Precision clock for PCs

DCF77 receiver module	59.00
DCF77 ferrite antenna	6.95
E406 case	7.50
BF245B	1.75
TL071CP	1.85

VHF/UHF TV tuner - 2

UV816PLL tuner module or eq.	99.00
PCF8582EP	4.95
SFH505A	11.00
Digitast press key incl. cap	2.95
10 MHz crystal	4.10
113CNSK1272HM81091 or eq.	4.75
199CASA359HM81008 or eq.	4.75
B80C1500	4.00
ZTK33 = 1N4752A	3.75
BF256B	1.75
4µH7 choke	0.85
15µH choke	0.85
TDA3857	14.75
TDA8415	22.50
TDA3842	14.75
LM339	1.95
SFE5.74	4.00
SFE5.5	3.50
TPS5.5MB	6.50
OFWG9250*	9.85
OFWG1963*	9.85
Spade terminal PCB mount	0.90

* delivery from week 3, 1994.

October 1993

Ah meter with digital display

RC4151NB	2.95
TLC274CN	4.60
HD1107	5.00

Microcontroller-driven NiCd charger

1N5400/5401	1.15
BYW29-100	2.85
BUZ10A	4.75
BD240	1.85
BD239	1.85
74HC239N	2.85
4805CV	4.50
Spade terminal PCB mount	0.90
SK47/100/SA heatsink	49.00

P&P 10.00

Autoranging frequency readout

74C925	36.00
SPG8651B	32.00
HD1133O	5.00

MIDI channel monitor

CNY17-1	1.35
PCB-mount 5-way DIN socket	1.75

September 1993

950-1750 MHz converter

MAR-6	9.95
AS-SAT5601 module	49.75
10kΩ multiturn pot	19.75
100kΩ multiturn pot	19.75
B40C1500	4.00
LM317T	3.25
LC860 case	39.50

P&P 12.50 (Europe)

P&P 20.00 (outside Europe)

PC-aided transistor tester

ZN425	27.50
LM358N	0.95
TLC1541	29.50
LM317T	3.25
LM337T	3.25
36-way PCB mount Centronics socket	9.50

June 1993

VHF/UHF receiver

Kit, incl. case and PCB, excl. mains transformer **345.00**

P&P (Europe)	25.00
P&P (outside Europe)	35.00

Individual parts:

2200µF 40V pitch 10mm	6.75
3mm ferrite bead	0.75
1µH5 choke	0.85
KACS1506 Toko	4.75
B80C1500	4.00
TAA550 = ZTK33 = 1N4752A	3.75
BF256C	1.75
NE605N/NE615N	17.50
CA3240E1	1.45
TDA7052	2.75
7806	1.45
UV616S/6456 or equivalent	109.00
SFE10.7MA filter	4.25
G1968 filter	9.85
48MHz xtal	4.10
1-pole 4-way rotary switch	3.35
LC860 case	39.50

P&P 12.50 (Europe)

P&P 20.00 (outside Europe)

We have much more than can be listed here SEND FOR COMPLETE PRICE LIST

C-I Electronics · P.O. Box 22089 · 6360 AB Nuth · Holland

Fax*: (+31) 45 241877

* Faxed enquiries may be answered by mail. Please always fax your complete address.

Enclose one IRC with all correspondence. Prices are in Dutch guilders (NLG), subject to change without prior notice, and exclusive of postage and packing.
No currencies other than NLG (Netherlands Guilders) accepted.
Private customers in EEC countries add BTW (sales tax) at 17.5%, then P&P.
Companies and institutions: please state your Intrastat VAT number.
Goods sent by airmail, recorded delivery. No C.O.D. orders.
P&P components: NLG 12.50 (outside Europe); NLG 8.50 (Europe).

VISA - MASTER - ACCESS - EUROCARD orders welcome

MICRO-CONTROLLER DEVELOPMENT SYSTEMS
8748/9 Series and 8751 Series
NO EMULATOR OR PROGRAMMER REQUIRED

A customer recently said "*Your system has proved an excellent and very economic way for a hobbyist to get into Embedded Microprocessors*"
D.S. (CEng M.I.E.E) Southend-on-Sea

KARE 48 8748/9 System. Recommended for beginners.
Includes Single Board Computer. Using 8749 OTP Micro with built-in Monitor/Downloader prog . Allows downloading of assembled progs to non-volatile 2K memory. Edit individual bytes and examine memory. Switch to external memory to run loaded program. Comes complete with Shareware Editor, Assembler and Comms package, RS232 inter-connect lead. All IC'S socketed. In fact all you need, is an IBM compatible PC and a 5v power supply. Software available on 3.5 or 5.25. Please note no charge is made for software, and will require registration for continued use **Built £64.88 +VAT** **Kit £49.00 + VAT**

KARE 51 8751 System
As above but using 8751 OTP Micro with Monitor/Downloader program
Built £75.74 + VAT **Kit £59.00 + VAT**

MICRO CONTROLLERS

80C31 d. i. l. Plastic **£3.00 + Vat** • P80C32 d. i. l. Plastic **£5.00 +Vat**

D87C51 Eprom Ceramic **£21.00 + Vat** • D8748H Eprom Ceramic **£6.00 + Vat**

Printed circuit board for 8040 + latch + 2K memory, PCB only **£4.00 + Vat**

Printed circuit board for 8031/2 + latch + 2K memory, PCB only **£5.00 + Vat**

PLEASE ADD £1.50 + V.A.T. P&P TO ORDERS FOR DEV KITS, MICRO'S & PCB'S.

PC EPROM PROGRAMMER
Internal Card for PC, XT, AT, 386, 486 or Compatible - £128 +VAT

ADD P&P £4.00 + V.A.T.

- **Affordable**
- **Easy to instal, just plug in.**
- **Programs E(E)proms and flash memory**
- **Supports 2716 through 27C2001 EPROMS.**
- **Reads, programs, verifies and saves to disk.**
- **Accepts Intel hex, Motorola S, and binary format.**
- **Requires 8-bit bus slot of MS-DOS PC with 512K ram.**
- **Supplied with software and 60 page handbook**
- **1 year warranty**
- **MICRO ADAPTORS AVAILABLE £35.00** +VAT

STAND-ALONE PROGRAMMERS also available.
Call us today for further information and DEMO DISK

KARE ELECTRONICS
32 Pear Tree Avenue, Ditton, Aylesford,
Kent. ME20 6EB. Tel: 0732 844633

WE HAVE THE WIDEST CHOICE OF USED OSCILLOSCOPES IN THE COUNTRY

TEKTRONIX 7000 SERIES OSCILLOSCOPES Dual Trace Plug-in with TB from **£200** Many Plug-in options available. 4 Trace; Differential etc.

PLUG-INS SOLD SEPERATELY

TEKTRONIX 2235 Dual Trace 100 MHz Delay Sweep	**£800**
H.P. 1722B Dual Trace 275MHz Delay Sweep LED readout	**£550**
PHILLIPS 3065 2+1 Channels 100MHz Dual TB Delay Sweep	**£700**
H.P. 1715A Dual Trace 200MHz Delay Sweep	**£500**
TEKTRONIX 465 Dual Trace 100 MHz Delay Sweep	**£450**
H.P. 1740A Dual Trace 100MHz Delay Sweep	**£400**
PHILLIPS PM3217 Dual Trace 50MHZ Delay Sweep	**£400**
IWATSU SS5705. 3 channel 40MHz Delay Sweep	**£400**
TELEQUIPMENT D83 Dual Trace 50MHz Delay sweep	**£200**
TRIO CS1830 Dual Trace 30MHz Delay Sweep	**£300**
KIKUSUI 5530 Dual Trace 35MHz	**£180**
GOULD OS1100 Dual Trace 30MHZ	**£160**
GOULD OS300 Dual Trace 20MHz	**£200**
GOULD OS250B Dual Trace 15MHz	**£125**
TEKTRONIX 466 Storage 100Mhz. Delay	**£450**

THIS IS JUST A SAMPLE - MANY OTHERS AVAILABLE

PHILLIPS PM5193 Programmable synthesizer/ Function Generator 0.1MHZ - 50MHZ IEEE-488. As new £1500

MARCONI 2019 Synthesized AM/FM Sig Gen 80KHz-1040MHz	**£2000**
MARCONI 2018 Synthesized AM/FM Sig Gen 80KHz 520M Hz	**£950**
EIP/DANA 341D Microwave Frequency Counter 20Hz 18GHz	**£950**
RACAL 9921 Frequency Counter 3GHz	**£300**
H.P. 339 Distortion Measuring Set 10Hz - 110KHz	**£1500**
RACAL/DANA 1991Nanosecond Universal Counter	**£800**
RACAL 9302 RF Millivoltmeter True RMS 10KHz 1.5GHz	**£450**
RACAL 9301A RF Millivoltmeter True RMS 10KHz 1.5GHz	**£300**
RACAL 9009 Automatic Mod. Meter 10MHz-1.5GHz Wide Deviation	**£250**
H.P. Pulse Generator type 214B	**£750**
LYONS PG73N Pulse Gen. PRF 1Hz - 20MHz	**£150**
FARNELL PSG520 Syn. AM/FM Sig. Gen 100KHz - 520MHz	**£800**
LEADER LSG216 AM/FM Sig. Gen 2 Ranges 0.1-30MHz & 75-115MHz	**£400**
KEITHLEY 197 51/2 Digit Autoranging Microvolt DMM with IEEE	**£250**

CHASE HFR2000 INTERFACE
Measuring Receiver with mains network
£1750

SPECTRUM ANALYSERS

H.P. 141T with 8555A & IF Plug-In 10MHz - 18GHz	**£1800**
H.P. 141T with 8554B & 8552B. 500KHz - 1250MHz	**£1300**
H.P. 140T with 8554L & 8552A 500KHz 1250MHz	**£1000**
H.P.141T with 8556A & 8552B 20Hz - 300KHz	**£1000**
H.P. 140T with 85536 & 8552A 160Hz - 110MHz	**£800**
MARCONI TF2370. 1KHz - 110MHz	**£1500**
H.P. 182C with 8558B 100Hz - 1500MHz	**£1500**
H.P. 3582A 0.02Hz - 25.5KHz	**£2000**

DATRON 1061A -6 5 digit Autocal Multimeter with True RMS AC/Current	**£1250**
DATRON 1065 -5.5 digit Autocal Multimeter with AC/DC/Ohms with IEEE	**£600**
HEWLETT PACKARD 3490A Bench Multimeter. 5 Digit AC/DC/Ohms	**£200**
PHILLIPS PM2534 Multi Function DMM 3.5 6.5 digit with GPIB/IEEE	**Only £450**
MARCONI Digital Frequency Meter 2430A 10Hz 80MHz	**£125**
MARCONI Digital Frequency Meter 2431A 10Hz 200MHz	**£150**
MARCONI Universal Counter Timer 2437 DC 100MHz	**£175**
MARCONI Universal Counter Timer 2438 DC 520MHz	**£225**
FEEDBACK FG600 Sine/Sq/Tri 0.01Hz-100KHz	**£60**
MULTIMETERS HAND HELD M2355 -32 ranges AC/DC 10 Amps Diode/Transistor Tester; Freq counter	**£32.50**

FARNELL ELECTRONIC LOAD RB1030 - 35
1KW 30Amp 35 Volt **£600**

H.P. 8690B Sweep Osc with 86974 Plug-in. 26.5 40GHz	**£300**
RACAL /DANA RF Power Meter 9104	**£400**
RACAL/DANA 9341 Databridge Automatic L.C.R. & Q.	**£350**
WAYNE KERR B905 Automatic Precision Bridge 0.05%	**£900**
WAYNE KERR B605 Automatic Component Bridge 0.1%	**£350**
WAYNE KERR B424 Digital LCR Meter	**£125**
COSSOR 108L Optical Cable Fault Locator	**£1500**
BICCOTEST T431M Cable Test Set	**£1000**
FARNELL PSU. TVS70MK2. 70V 5A/30V 10A	**£300**
FARNEL PSU H60/25 0-60V; 0-25Amps Metered	**£400**
FARNEL PSU L30E 0 30V; 0 5Amps Metered	**£80**
FARNEL B30/20 0-30V. 20Amps	**£250**
FARNEL B20/10 0 30V. 10Amps	**£200**
MARCONI TF2700 Universal LCR Bridge. Battery from	**£150**
AVO Valve Characteristic Meter VCM163	**£300**
FARNELL LA520 RF Power Amp. 1 5-520MHz 300mW	**£175**
RACAL 9100 Absorption Wattmeter 1MHz 1GHz 3W	**£100**
TRIO Wow & Flutter Meter FL190	**£200**
H.P. 3311A Function Gen. 0.2Hz-1MHz Sine/Sq/Tr	**£125**
KIKUSUI AVM23 AC Voltmeter Dual 10Hz 500MHz1	**£100**

FARNELL ISOLATING TRANSFORMERS
GU500 240V 500VA **Un-Used £50**

ISOLATING TRANSFORMERS 500VA **UnCased £30**

NEW EQUIPMENT

HAMEG OSCILLOSCOPE HM 1005 Triple Trace 100MHZ Delay Timebase	**£847**
HAMEG OSCILLOSCOPE HM 604 Dual Trace 60MHZ. Delay Sweep	**£653**
HAMEG OSCILLOSCOPE HM203.7 Dual Trace 20MHZ. Component Tester	**£362**
HAMEG OSCILLOSCOPE HM205.3 Dual Trace 20MHZ. Digital Storage	**£653**

All other models available - all oscilloscopes supplied with 2 probes

BLACK STAR EQUIPMENT (p&p all units £5)

APOLLO 10 100MHZ Counter Timer Ratio/Period/Time Interval etc	**£222**
APOLLO 100 100MHZ (As above with more functions)	**£325**
METEOR 100 FREQUENCY COUNTER 100MHZ	**£119**
METEOR 600 FREQUENCY COUNTER 600MHZ	**£145**
METEOR 1000 FREQUENCY COUNTER 1GHZ	**£189**
JUPITOR 500 FUNCTION GENERATOR 0.1 HZ-500KHZ Sine/Sq/Tr	**£119**
ORION COLOUR BAR GENERATOR Pal/TV/Video	**£229**

All other Black Star Equipment available.

OSCILLOSCOPE PROBES Switchable x1; x10 (P&P £3) **£12**

Used Equipment Guaranteed- Manuals supplied if possible
This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists. Please check availability before ordering CARRIAGE all units £16
VAT to be added to Total of Goods and Carriage

VISA

STEWART of READING
110 WYKEHAM ROAD, READING, BERKS RG6 IPL
Telephone: (0734) 268041 Fax (0734) 351696 Callers Welcome 9am-5.30pm Mon-Fri (until 8pm Thurs)

ACCESS

PCB DRILL CONTROL

The circuit in the diagram enables the speed of an electric PCB drill to be controlled with only one preset. As an aside, the rotary direction of the drill may be reversed. When the preset is at the centre of its travel, the drill stops.

The power supply delivers (immediately after the bridge rectifier) a voltage of about 12 V for the drill, and, by means of resistors R_{19} and R_{20}, and zener diodes D_6 and D_7, a symmetrical voltage of ±5 V for the electronic circuits. The ±5 V voltage is smoothed by C_6 and C_7. Diodes D_4 and D_5 prevent the motor of the drill being connected to the ±5 V section.

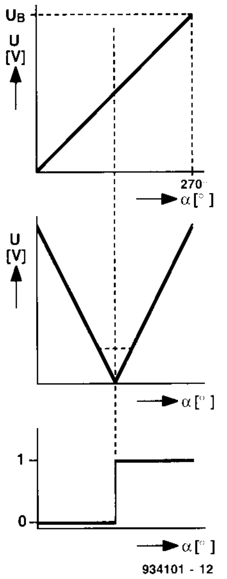
Speed control is effected with P_1, while rotary direction is determined by comparator IC_{1a}. This opamp ascertains whether the preset is to the left or to the right of its centre. On the basis of this, relay Re_1 is energized via T_1 or not, and this decides whether the drill turns clockwise or anti-clockwise.

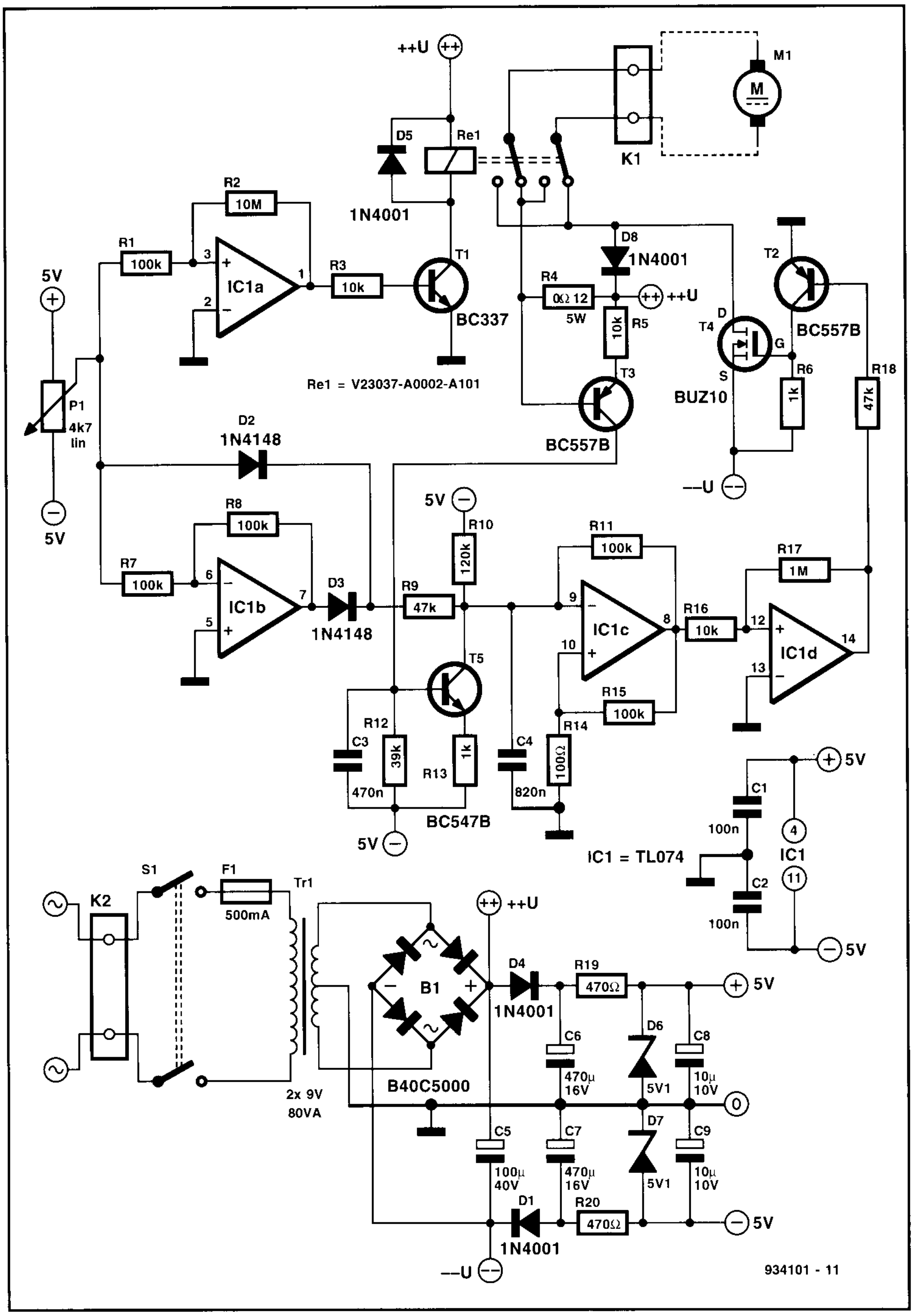
The speed control operates with pulse width modulation. The control (direct) voltage set with P_1 is applied to D_2 and IC_{1b}-D_3. This latter combination functions as a rectifier. Whether the voltage at the wiper of P_1 is negative or positive, it will appear as a positive potential (minus the 0.6 V forward bias of the diode) at the junction of D_2 and D_3.

The modulator is formed by IC_{1c}. This stage is designed as a rectangular-wave generator, which causes C_4 to be charged and discharged continuously via R_{11}. The setting of P_1 determines (via R_9) in conjunction with R_{10} how much additional direct voltage is applied to C_4, and thus the pulse/spacing ratio at the output of IC_1. Inverter IC_{1d} enhances the transitions (edges) of the signal, which are thereupon used to switch the power FET (T_4) via T_1.

When the drop across R_4, which is in series with the drill motor, rises to slightly more than 0.6 V (that is, when the current through the motor is about 5 A), T_3 will switch on, whereupon T_5 will reduce the pulse width slightly.

[H. Bonekamp - 934101]





SURVEILLANCE

PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the word! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range........£16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range........£13.45

STX High-performance Room Transmitter
Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range........£15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range........£16.45

VXT Voice Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range........£19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range........£22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range........£23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation........£22.95

ATR2 Micro Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line........£13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dil switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits)........£50.95
Individual Transmitter DLTX........£19.95
Individual Receiver DLRX........£37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range........£20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use.
All conversation transmitted. Powered from line. 500m range........£15.95

TLX700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range........£13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm.
1500m range........£16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation........£22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tome increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation........£30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation........£50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catlogue). Size 20mm x 67mm. 9V operation. 1000m range........£40.95

QLX180 Crystal Cointrolled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range........£40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m........£35.95

QRX180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation........£60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £1.50 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

OUR LATEST CATALOGUE CONTAINING MANY MORE NEW SURVEILLANCE KITS NOW AVAILABLE. SEND TWO FIRST CLASS STAMPS OR OVERSEAS SEND TWO IRCS.

SUMA DESIGNS

DEPT. EE
THE WORKSHOPS, 95 MAIN ROAD,
BAXTERLEY. NEAR ATHERSTONE,
WARWICKSHIRE CV9 2LE
VISITORS STRICTLY BY APPOINTMENT ONLY

☎
Tel: 0827 714476
Fax: 0827 714476

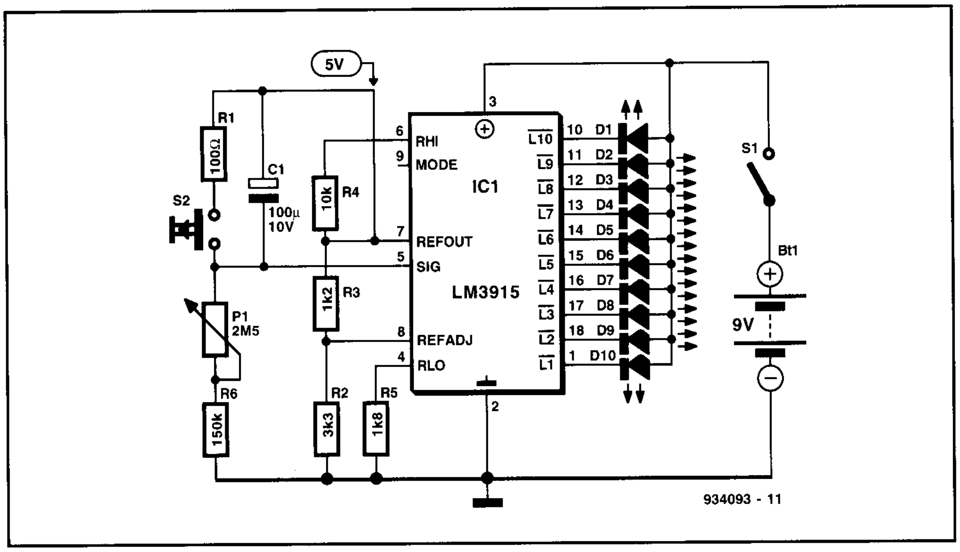
BASIC TIMER (II)

The timer is based on the well-known display driver LM3915, which has a logarithmic scale. This may seem strange, but is not because a simple RC network is used for time measurements. The voltage across this network, R_6-P_1-C_1, has, while C_1 is being charged, an exponential character ($U = U_{ref} \cdot e^{-t/RC}$). When this is applied to IC_1, which takes its logarithm, the time is shown linearly on the display. The values of P_1 and R_6 have been chosen to enable the timer showing periods of 1–15 minutes.

The timer is reset (C_1 is discharged) when S_2 is closed. Resistor R_1 limits the peak value of the discharge current from C_1 to an acceptable value for the switch contacts.

Resistor R_5 compensates the leakage currents of the electrolytic capacitors to obviate the risk of D_{10} going out.

If pin 9 of IC_1 is left open, the display is in the dot mode. The elapsing of time is then shown by only one LED lighting. After a reset, D_1 will light first and then, sequentially, all the other LEDs.



The total current drawn by the timer is 20 mA, so that battery supply is possible.

When pin 9 is connected to pin 3 (+ve supply line), the display is in the bar mode. After a reset, all LEDs will light and then go out in turn, starting with D_1. In this mode, battery supply is not recommended.

[H. Bonenkamp - 934093]

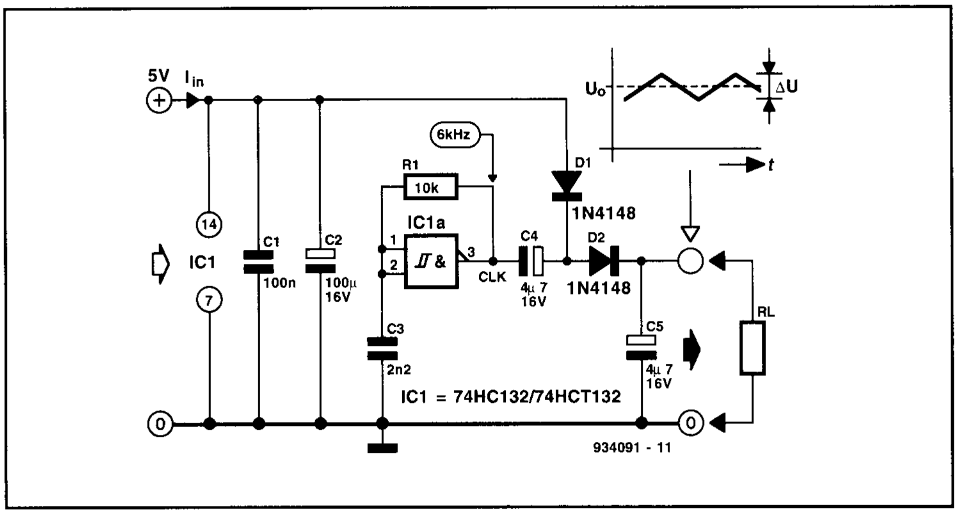
INEXPENSIVE VOLTAGE DOUBLER

Voltage doublers are frequently encountered in electronic circuits. The present one is a variation that is of interest since most digital circuits already have a buffered clock (CLK) available or have a spare Schmitt trigger gate. Since in those cases no new IC is needed, the cost of the doubler is much reduced.

If a buffered CLK signal is available, only four components, C_4, C_5, D_1 and D_2, are required to produce a voltage of 10 V from the 5 V supply. If an oscillator needs to be built from a spare gate, two further components are needed: R_1 and C_3.

The most important parameters of the circuit are given in the table. Note that, owing to tolerances in the clock circuit, these data may be slightly different.

[J. Ruiters - 934091]



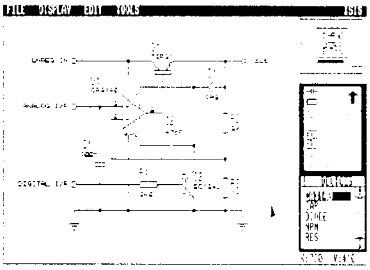
R_L [Ω]	U_0 [V]	ΔU [mV$_{pp}$]	I_{in} [mA]	n [%]
--	9.4	0	2.4	--
2200	8.0	15	20.0	29
780	7.0	40	28.3	45
460	6.0	80	37.6	41

EASY FAST & POWERFUL

CAD SOFTWARE THAT GIVES YOU THE EDGE

ISIS - SCHEMATIC CAPTURE

Easy to use yet extremely powerful schematic entry system with all the features you need to create input for ARES or other CAD software. Now available in a super-fast 32 bit version capable of handling huge designs even on A0-sized sheets.



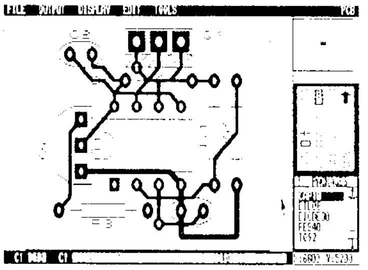
- Graphical User Interface gives exceptional ease of use - two mouse clicks will place & route a wire.
- Automatic wire routing, dot placement, label generation.
- 2D drawing capability with symbol library.
- Comprehensive device libraries.
- Heterogeneous devices (e.g. relay and coil) allowed in different places on the schematic.
- Special support for connector pins - put each pin just where you want it.
- Output to printers, plotters, Postscript.
- Export designs to DTP and WP packages.
- Netlist formats for most popular PCB & simulation software.
- Bill of Materials and Electrical Rules Check reports.
- Multi-sheet and hierarchical design support.
- Automatic annotation/packaging.
- ASCII data import database facility.

from

£275

ARES - PCB DESIGN

Advanced netlist based PCB layout software newly updated to version 2.5. Major new features include SMT library, real time snap (for those tricky SMT spacings), thermal relief power planes and enhanced autorouting.



- Graphical User Interface.
- Real time snap.
- Auto track necking.
- Curved, 45/90 or any angle tracks.
- Extensive through hole and SMT package libraries as standard.
- 2D drawing capability with symbol library.
- Connectivity highlight.
- Output to printers, plotters, Postscript, Gerber and NC drill.
- Gerber View facility.
- Graphics export for DTP etc.
- Advanced netlist management with forward design modification.
- Component renumber and back-annotate to ISIS.
- Full physical and electrical design rule checks.
- Autorouter handles single, double or multi-layer boards.
- Power plane generator with reliefs.
- Strategy & DRC information loadable from ISIS.
- Gerber import utility available.

from

£275

ISIS ILLUSTRATOR

Schematic capture for MS Windows 3.1 - produces high quality schematics like you see in the magazines with your choice of line thicknesses, fill styles, fonts, colours etc. Once entered, drawings can be copied to most Windows software through the clipboard.

New version 2 includes netlisting, bill of materials, hierarchy, and much more. An ideal front end for Windows Simulation and PCB design.

new low prices from

£99

CADPAK - BUDGET PRICE CAD

Two programs - ISIS SUPERSKETCH and PCB II - for the price of one.

CADPAK has everything you need to produce circuit diagrams and PCBs on your PC and is exceptionally easy to use.

superb value at only

£79

Labcenter
Electronics

*Call us today on **0274 542868** or fax **0274 481078** for a demo pack. Combination, multi-copy and educational discounts available. Prices exc P&P and VAT.*

14 Marriner's Drive, Bradford, BD9 4JT.

SYMMETRICAL POWER SUPPLY

A symmetrical power supply may be designed from two standard opamps, but it can only provide a small current (of the order of a few mA).

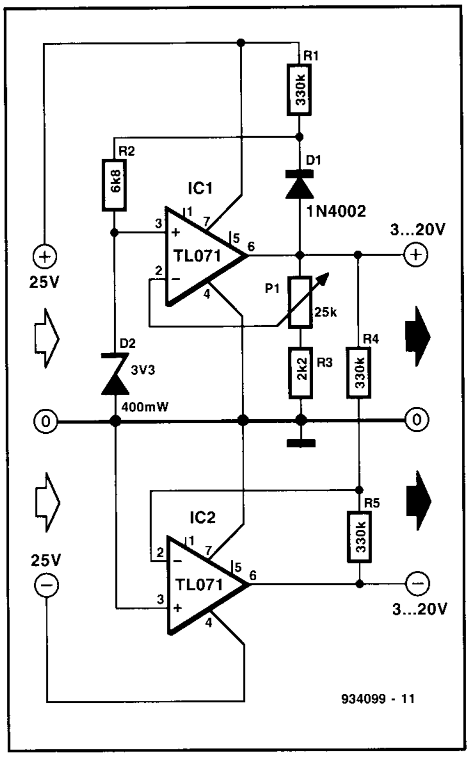
In the diagram, the upper half provides the positive voltage. A 3.3 v zener diode, connected to the non-inverting (+) input of opamp IC_1, serves as reference. To ensure correct starting of the circuit, the diode is initially powered via R_1 and when the output voltage is sufficiently high via D_1. Part of the output voltage is fed back to the inverting (–) input of IC_1 viaP_1. The lower the feedback voltage, the higher the output.

The supply voltage for the TL071 may be 36 V maximum, so that the output voltage can go up to about 30 V. It is, however, safer to make the supply to the opamp rather lower and accept a slightly lower output voltage.

The lower part of the diagram is a mirror of the upper part: it provides the negative output. Opamp IC_2 needs an additional (negative) supply voltage.

The output voltages may be made more stable by connecting a 10 µF electrolytic capacitor across each of the outputs.

[Amrit Bir Tiwana - 934099]



VIDEO DATA CHANGE DETECTOR

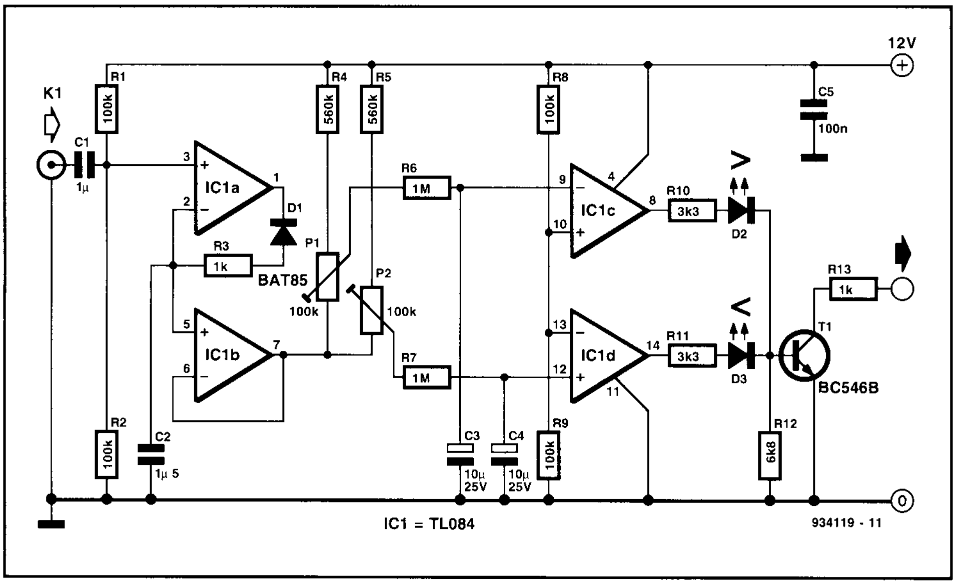
The circuit detects a change in video information and uses this to switch on an alarm in a closed-circuit television guard system or a video recorder.

The circuit is usable only where the same picture is shown on the TV monitor for some time. When the picture changes, the average brightness alters and this is detected by a window comparator.

Capacitor C_1 prevents any d.c. component in the video signal reaching the circuit. Opamp IC_{1a} clamps the signal. On average, the potential at pin 3 of IC_{1a} is always equal to half the supply voltage.

The potential across C_2 is buffered by IC_{1b}. The output signal of this opamp is applied to window comparator IC_{1c}-IC_{1d} via presets P_1 and P_2.

The reference voltage for the comparator is held at half the supply voltage ($^1/_2\ U_b$) by R_8-R_9. Preset P_1 is adjusted to make the potential at its wiper slightly higher than $^1/_2\ U_b$, and P_2 to make its wiper voltage slightly lower than $^1/_2\ U_b$. The potentials at the wipers of P_1 and P_2 are applied to the comparator via fairly long (>10 s) time constants (R_6-C_3 and R_7-C_4). The smaller the set window, the faster the reactor will change state.



When the level of the input signal rises, the potential across C_2 decreases, whereupon the levels across P_1 and P_2 also drop. When the voltage at pin 9 of IC_{1c} drops below $^1/_2\ U_b$, the output of this stage goes high. This change of state, indicated by the lighting of D_2, is used to give an external apparatus a trigger or start pulse of up to 65 V via the open collector output of T_1. Resistor R_{13} serves as a current limiter.

When the level of the input signal decreases, a similar action follows, but in this case IC_{1d} changes state, which is indicated by the lighting of D_3.

When there is no change in the average input signal, T_1 remains off.

The circuit draws a current of about 12 mA.

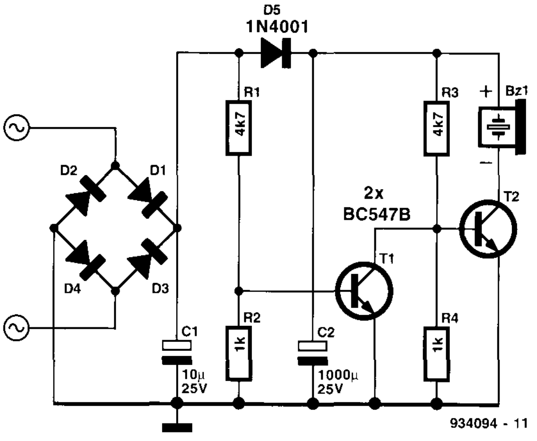
[T. Giesberts - 934119)

COMPLEMENTARY DOORBELL

It is often not possible to put a second bell in parallel to the existing one, because the bell transformer is normally already fully loaded. The circuit proposed here offers a solution to this problem.

The buzzer sounds **after** the bell-push has been released, The energy for this is stored in capacitor C_2 while the bell-push is pressed. This causes only a small (and brief) additional load on the bell transformer. At the same time, T_1 ensures that T_2 is off. When the bell-push is released, T_1 is switched off and T_2 begins to conduct. As long as the charge on C_2 lasts, the buzzer will sound. The length of the sound depends on the value of C_2 (the higher the value, the longer the sound). Since all the energy is supplied by C_2, the buzzer cannot be replaced by a normal bell or gong, since these draw far too large a current.

[A. Rietjens - 934094]



STORAGE OSCILLOSCOPE TESTER

The tester generates two different signals for checking a digital storage oscilloscope. The first is a stepped voltage on to which glitches are superimposed; the second is a rectangular 2 kHz signal on to which a 15 Hz analogue signal is superimposed.

The first signal quickly shows whether the oscilloscope eliminates the glitches during signal processing. If it does, the measurements cannot be fully trusted. It can also be used to check the trigger function; if this is poor, it will not be able to cope with the signal properly.

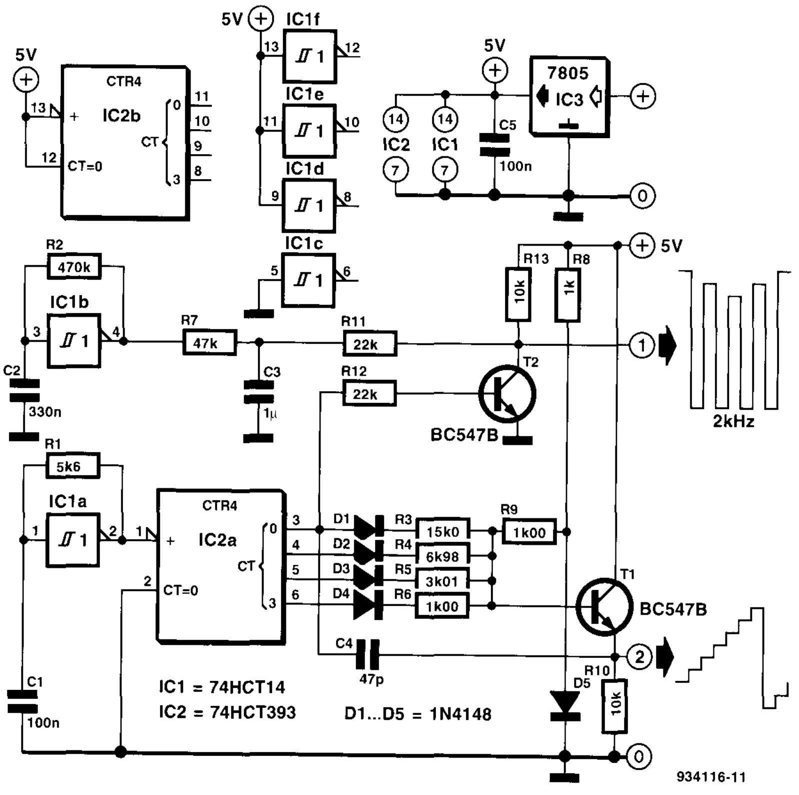
The second signal shows whether at a given setting low-frequency signals remain clearly visible (they should).

The stepped voltage is generated by oscillator IC_{1a} and a digital-to-analogue converter (DAC)—see diagram. The converter consists of IC_2, D_1–D_4, R_3–R_6, and R_9. The signal is buffered by T_1. Diode D_5 compensates the forward bias of the base-emitter junction of T_1. The spikes are introduced by C_4.

The second signal is produced by switching T_2 in rhythm with the 2 kHz signal and changing the collector voltage with the 15 Hz signal generated by oscillator IC_{1b}.

The circuit needs a supply voltage of 9–15 V and draws a current of about 50 mA.

[A. Rietjens - 934116]



HEXADECIMAL DISPLAY DECODER

The byte-to-hex display decoder was designed because nibble-to-hex decoders are no longer produced commercially. In principle, it is of, course, not difficult to decode a nibble, but from byte to hex is generally more practical and requires fewer ICs. The decoder uses a GAL Type 22V10. This type has an adequate number of inputs and outputs for the present application and may be programmed with the 'GAL programmer' (incl. the extension) published in this magazine[1]. The listing and programming data shown are written in the format that is accepted by the National Semiconductor software and may be converted to a JEDDIC file with the EQN2JED option. Note that although a warning is generated that in the define statements an OR term is used, this is a false alarm, since in the present circuit no fewer than eight OR terms are produced.

The circuit has a drawback in that it requires an external clock. Fortunately, this signal can often be derived from the circuit to which the display is connected. The frequency may be between 100 Hz and 100 kHz.

Apart from clocking the bistables at the outputs of the GAL, the clock also serves the multiplexing of the two displays.

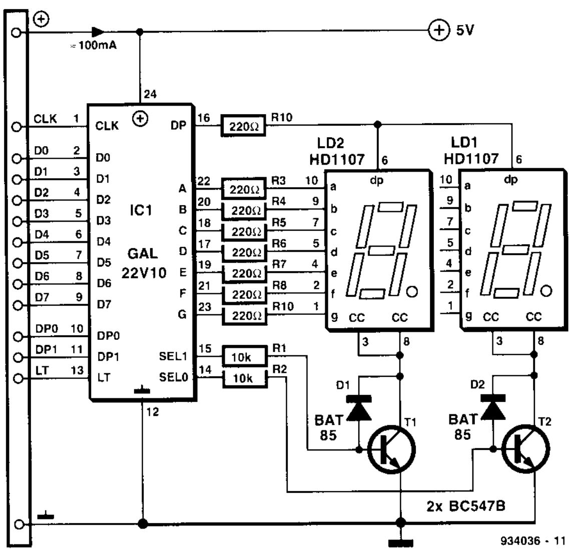
Schottky diodes D_1 and D_2 ensure that T_1 and T_2 switch off fast, so that the transistors are on in turn without any overlap. This prevents 'ghost' segments arising at clock frequencies above 1 kHz.

LT is a lamp-test input with which all segments are controlled. A '1' at input DP0 or DP1 causes the relevant decimal point on the displays to light.

The decoder may serve as an example for the design of a special decoder for another application.

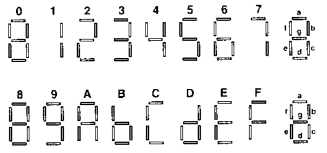
[A. Rietjens – 934036]

1



2

```
    Hex Decoder / 7-Segment LED Driver
    GAL file for OPAL Junior

CHIP hex_7seg gal22v10

clk d0   d1   d2 d3 d4 d5 d6 d7 dp0 dp1 gnd
lt  sel0 sel1 dp d  c  e  b  f  a   g   vcc

;define product terms for each value and each display

    @define zero      "/d7*/d6*/d5*/d4*/lt*sel0+/d3*/d2*/d1*/d0*/lt*sel1"
    @define one       "/d7*/d6*/d5* d4*/lt*sel0+/d3*/d2*/d1* d0*/lt*sel1"
    @define two       "/d7*/d6* d5*/d4*/lt*sel0+/d3*/d2* d1*/d0*/lt*sel1"
    @define three     "/d7*/d6* d5* d4*/lt*sel0+/d3*/d2* d1* d0*/lt*sel1"
    @define four      "/d7* d6*/d5*/d4*/lt*sel0+/d3* d2*/d1*/d0*/lt*sel1"
    @define five      "/d7* d6*/d5* d4*/lt*sel0+/d3* d2*/d1* d0*/lt*sel1"
    @define six       "/d7* d6* d5*/d4*/lt*sel0+/d3* d2* d1*/d0*/lt*sel1"
    @define seven     "/d7* d6* d5* d4*/lt*sel0+/d3* d2* d1* d0*/lt*sel1"
    @define eight     " d7*/d6*/d5*/d4*/lt*sel0+ d3*/d2*/d1*/d0*/lt*sel1"
    @define nine      " d7*/d6*/d5* d4*/lt*sel0+ d3*/d2*/d1* d0*/lt*sel1"
    @define ten       " d7*/d6* d5*/d4*/lt*sel0+ d3*/d2* d1*/d0*/lt*sel1"
    @define eleven    " d7*/d6* d5* d4*/lt*sel0+ d3*/d2* d1* d0*/lt*sel1"
    @define twelve    " d7* d6*/d5*/d4*/lt*sel0+ d3* d2*/d1*/d0*/lt*sel1"
    @define thirteen  " d7* d6*/d5* d4*/lt*sel0+ d3* d2*/d1* d0*/lt*sel1"
    @define fourteen  " d7* d6* d5*/d4*/lt*sel0+ d3* d2* d1*/d0*/lt*sel1"
    @define fifteen   " d7* d6* d5* d4*/lt*sel0+ d3* d2* d1* d0*/lt*sel1"

;define combined productterms to minimize the total number of terms

    @define or14or15 " d7* d6* d5*/lt*sel0+ d3* d2* d1*/lt*sel1"
    @define or11or15 " d7* d5* d4*/lt*sel0+ d3* d1* d0*/lt*sel1"
    @define or12or14 " d7* d6*/d4*/lt*sel0+ d3* d2*/d0*/lt*sel1"
    @define or2or3   "/d7*/d6* d5*/lt*sel0+/d3*/d2* d1*/lt*sel1"
    @define or4or5   "/d7* d6*/d5*/lt*sel0+/d3* d2*/d1*/lt*sel1"
    @define or7or15  " d6* d5* d4*/lt*sel0+ d2* d1* d0*/lt*sel1"
    @define or1or9   "/d6*/d5* d4*/lt*sel0+/d2*/d1* d0*/lt*sel1"
```



```
    EQUATIONS

;To minimize product terms the segment selection is done by using
;the one's that are off, and several options, like 'one+nine', are combined
;into one product term, resulting in one term 'or1or9'.
;All outputs are registered and the multiplex frequency is determined by
;the supllied clock frequency

/a:= one    + four   + eleven   + thirteen
/b:= five   + six    + or11or15 + or12or14
/c:= two    + twelve + or14or15
/d:= four   + one    + ten      + or7or15
/e:= or1or9 + three  + or4or5   + seven
/f:= one    + or2or3 + seven    + thirteen
/g:= zero   + one    + seven    + twelve

sel0 := sel1
sel1 := /sel1

dp:= dp0*sel1 + dp1*sel0
```

934036 - 12

---

[1] May 1992.

BADGER BOARDS

Printed Circuit Boards for Amateur Radio Schools Colleges Short Wave Listeners Clubs Hobbyists & Industry

A range of Printed Circuit Boards in stock from many of the Projects in Magazines PRACTICAL WIRELESS ☐ SHORT WAVE MAGAZINE ☐ ELEKTOR☐ HRT RADIO COMMUNICATION

Kits Projects and Materials for manufacturing your own boards. Artwork and Plotting from your own Schematic drawings and also C.A.D. facilities. We supply ONE OFF Prototypes

Phone between **9.00am and 5.30pm Monday to Friday** for helpful advice and assistance

Club talks and demonstrations of Printed Circuit Board manufacture QRP involvement etc

021-353 9326

87, Blackberry Lane, Four Oaks, Sutton Coldfield. B74 4JF

(Please mention where you spotted this advertisement)

IF AN ADVERT IS WRONG, WHO PUTS IT RIGHT?

We do. The Advertising Standards Authority ensures advertisements meet with the strict Code of Advertising Practice.

So if you question an advertiser, they have to answer to us.

To find out more about the ASA, please write to
Advertising Standards Authority,
Department X, Brook House,
Torrington Place, London WC1E 7HN.

ASA

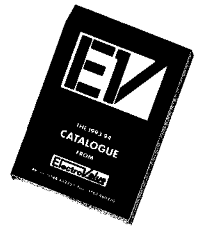
This space is donated in the interests of high standards in advertisements.

THIS IS THE COUPON

that brings the 1993/94

CATALOGUE

140 pages, A4, copiously illustrated, bang up to date and with bonus vouchers. Send cheque/PO for £1.50



that brings the

SERVICE

with choice of very wide ranges of famous-name quality electronic components and associated gear sent promptly on receipt of your order. *A service that* **ElectroValue** have been providing since 1965. With *this* Catalogue, you will find our service the best ever. Send for your copy **NOW!**

ELECTROVALUE LTD, 3, CENTRAL TRADING ESTATE, STAINES.
TW18 4UX. ***Tel: 0784 442253. Fax: 0784 460320***

I enclose Cheque/PO/Card no ....
value £1.50 for your **1993/4 CATALOGUE**

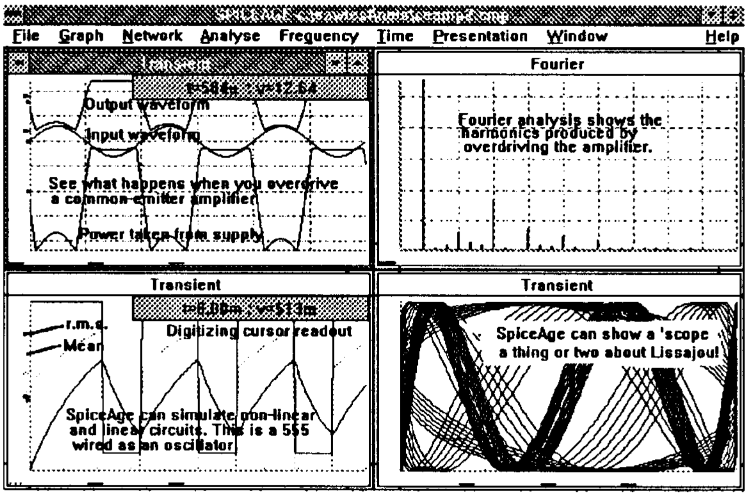
Name ....
Address ....
....
.... POST CODE K3

Those Engineers Ltd

SPECIAL OFFER

SpiceAge for Windows for £95 incl VAT for a limited period.

We are offering a special version of SpiceAge for Windows to students and serious hobbyists. The version will analyse medium sizes of circuits and may be upgraded to the professional version for the price difference.



See what happens when you overdrive a common-emitter amplifier

Fourier analysis shows the harmonics produced by overdriving the amplifier.

SpiceAge can simulate non-linear and linear circuits. This is a 555 wired as an oscillator

SpiceAge can show a 'scope a thing or two about Lissajou!

SpiceAge is the program used by professional circuit designers that lets you "breadboard" even before you plug in your soldering iron. It gives you quiescent DC voltages, frequency response curves and 'scope-like traces of your circuit ideas. Imagine how easy it is to test new components and values without the risk of smoke! SpiceAge has a friendly editor that lets you tell it what components to put in your circuit and how to connect them. SpiceAge has a "lab" full of "test equipment" to let you inject signals and "probe" for voltages, currents, dissipations, dB gains, phase angle, group delay and power consumption.

Requires Windows 3.0 or higher. S.A.E. please for information pack or £5 for demonstration kit. ACCESS/VISA or cheque with order. Please state disk size. Those Engineers Ltd, Dept Ek03, 31 Birkbeck Road, London NW7 4BP. Tel 081-906 0155, Fax 081-906 0969.

8-CHANNEL A-D CONVERTER

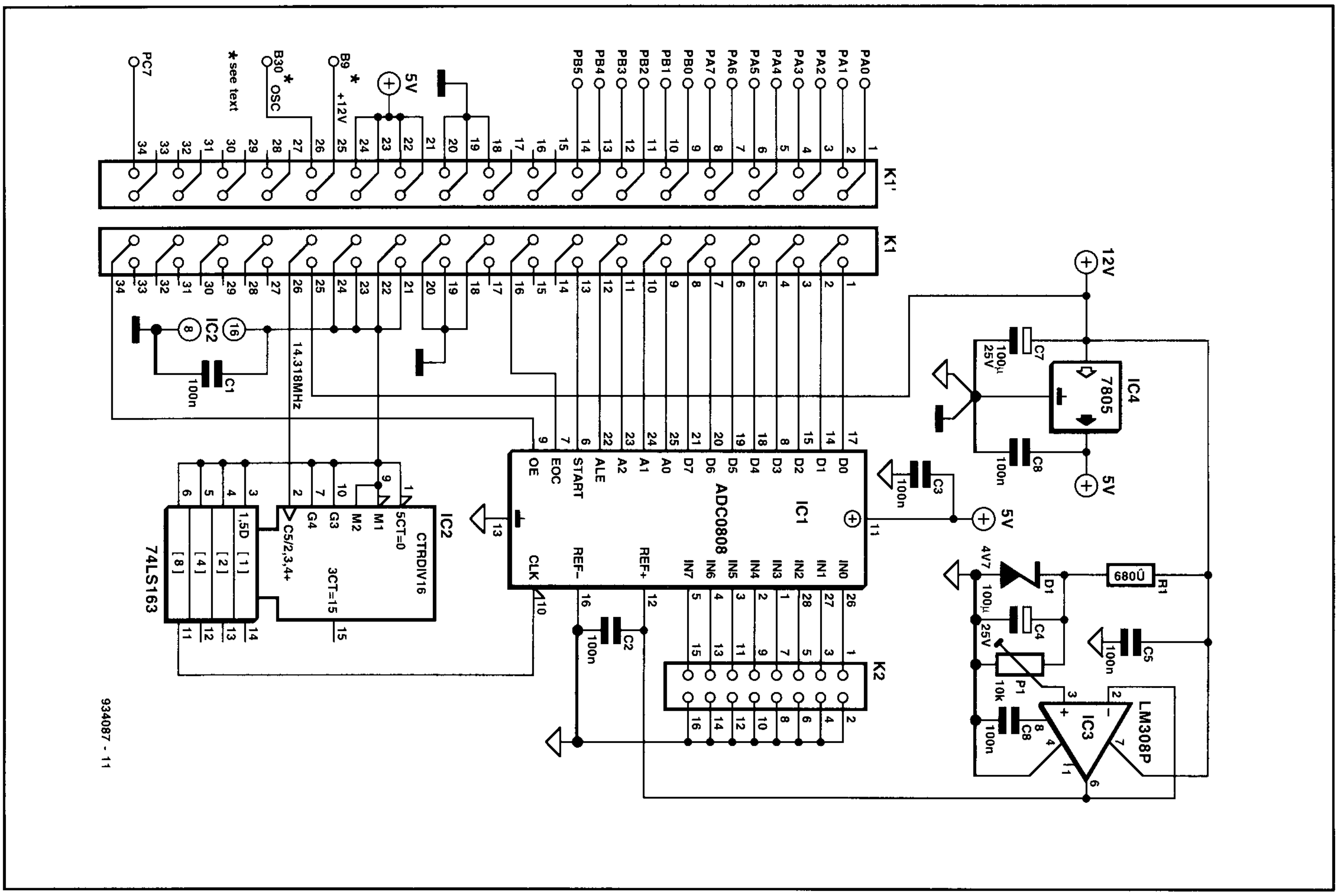
The converter described is controlled by a small I/O card that has an adequate number of inputs and outputs. It may be built on small piece of prototyping board and connected to the I/O board via K_1. The 12 V supply and the clock (OSC = 14.318 MHz) which, divided by 16, is used to clock the converter, are derived from the I/O card. The clock may also be drived from a PC, but that on the I/O card is independent of the computer.

How the converter is operated is shown in the BASIC program, except for one action. The EOC output (which goes high at the end of a conversion) needs a minimum of 0 clock pulses and a maximum of eight clock pulses plus 2 µs after the leading transition (edge) of the start pulse to go low. This means that with compiled software or machine language routines EOC must be checked in the correct manner (that is looking on line 200 whether EOC is high).

[S. Mitra - 934087]

```
10 CLS
20 CTRLWRD = &H99:      'Port A is input, B is output, C is input
30 BASEADDR = &H300:    'base address of 8255
40 PORTA = BASEADDR
50 PORTB = BASEADDR + 1
60 PORTC = BASEADDR + 2
70 CTRLADDR = BASEADDR + 3
80 CHANNEL = 0
90 '
100 OUT CTRLADDR, CTRLWRD:  'initialize 8255
110 '
120 OUT PORTB, CHANNEL:                'set input channel address
130 OUT PORTB, (CHANNEL  OR &H8):      'B3 HIGH enable address latch
140 OUT PORTB, (CHANNEL AND &HF7):     'B3 LOW
150 '
160 OUT PORTB, (CHANNEL  OR &H10):     'B4 HIGH start conversion
170 OUT PORTB, (CHANNEL AND &HEF):     'B4 LOW
180 '
190 EOC = 0:                           'wait for End Of Conversion
200 WHILE EOC<> &H80 : EOC = INP(PORTC) AND &H80: WEND
210 '
220 OUT PORTB, (CHANNEL  OR &H27):      'B5 HIGH enable ADC outputs
230 LOCATE 1,1:PRINT "Channel ";CHANNEL;" : ";INP (PORTA);"   "
240 OUT PORTB, (CHANNEL AND &HDF):      'B5 LOW disable ADC outputs
250 '
260 PRINT : PRINT "Press N for next channel or S to stop"
270 A$=INKEY$
280 IF (A$="N" OR A$="n") THEN GOTO 310
290 IF (A$="s" OR A$="S") THEN END
300 GOTO 150
310 '
320 CHANNEL = CHANNEL + 1
330 IF CHANNEL = 8 THEN CHANNEL = 0
340 GOTO 110
```

934087 - 12



934087 - 11

BATTERY DISCHARGER

When batteries are charged rapidly, the manufacturer usually recommends that after every fifth fast charge there is a 'normal' charge, that is, one at 0.1 C(apacity). That can, however, be done only if the battery is discharged. At the same time, the individual cells must not be discharged too much. If, for instance, one cell is flat and the others are still charged or nearly so, the polarity of the flat cell reverses and that must be prevented to save the battery. As a rule of thumb, a battery should be discharged to an average of 1 V per cell.

The diagram shows a circuit that is suitable for discharging nickel-cadmium (NiCd) as well as nickel-metal-hydride (NiMH) batteries. It is simple and inexpensive, but the components must be matched to the number of cells the battery contains.

As long as D_2 lights, the battery is discharged via R_4 and T_1. When the battery voltage drops below a value set with P_1, T_1 no longer gets a base current. The LED will then go out and the discharge circuit may be removed. The battery can then be charged.

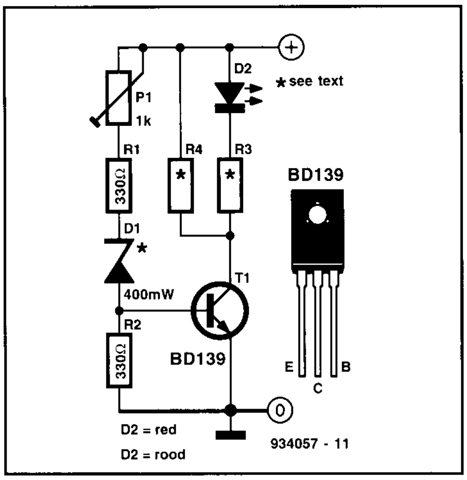
The circuit may be tested with the aid of a variable power supply with current limiting. Connect the discharger to the power supply: R_4 may be omitted. Set the output of the supply to the wanted level, whereupon T_1 should switch off. Adjust P_1 till D_2 lights dimly. This sets the voltage to which a battery may be discharged.

Since the gain is not very high, there is an area where D_2 diminishes gradually and where, therefore, the discharge current decreases gradually. This does not affect the circuit, however.

If the range is too small, the value of the zener diode should be reduced or increased.

The value of R_4 is calculated for a discharge current of about 0.5 A. This value is not critical. That is, if a resistor of 6.8 Ω proves difficult to obtain, a 4.7 Ω or 10 Ω resistor may be used without detriment. Since the voltage of the cells is monitored, it is not necessary to stabilize the discharge current.

[K. Walraven – 934057]

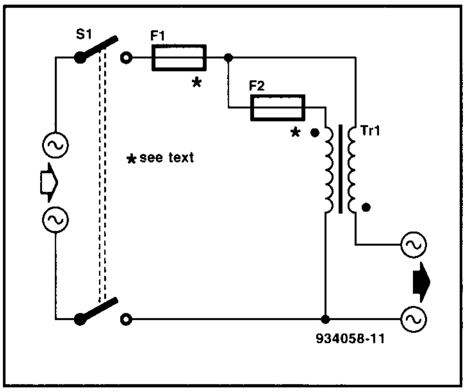


No. of cells	D_1 [V]	R_3 [Ω]	R_4 [Ω]
3	1.2 [2 diodes]	150	6.8 [5 W]
4	2.4 [3 diodes]	270	10 [5 W]
5	3.3	330	12 [5 W]
6	3.9	470	15 [10 W]
7	4.7	560	15 [10 W]
8	5.6	680	18 [10 W]
9	6.8	680	22 [10 W]
10	8.2	820	22 [10 W]

POWER BOOSTER FOR SLIDE PROJECTORS

The lamp in slide projectors is normally controlled with the aid of a triac in series with it. This method reduces the brightness of the lamp appreciably, since the triac drops about 1.5 V, which is more than 6% of the nominal lamp voltage. To compensate this loss, the mains voltage to the projector should be increased by that percentage. The transformer and ventilator can cope easily with that kind of increase, and so can any electronic circuits, since these are invariably powered via a regulator.

The a.c. voltage to the projector may be increased by connecting the secondary winding of a mains transformer in the live wire of the mains. The voltage developed across this winding is then added to the mains voltage (provided that the transformer is connected correctly as regards phase).



The voltage the secondary winding must deliver is calculated as follows. The current through the winding depends on the number of projectors and their rating. Assuming there are four, each rated at 250 W (power consumption: 300 W), the total power consumption during normal operation is 1200 W. With a mains voltage of 240 V, the current will be 5 A. Since the projectors do not all use full power simultaneously, the secondary winding may be rated at 6 A. The secondary voltage, U_s, should be the ratio of the loss across the triac and the nominal lamp voltage times the mains voltage, that is,

$$U_s = 1.5/24 \cdot 240 = 15\text{ V}.$$

Fuse F_1 should be rated at 1.25×the maximum current of all projectors. Assuming the earlier stated values, that is,

$$I_{\text{fuse1}} = 1.25 \cdot 1200/240 = 6.25\text{ A},$$

or, rounded off to the next standard value, 6.3 A (delayed action). The rating of fuse F_2 is calculated from

$$I_{\text{fuse2}} = 1.25 \cdot U_s \cdot I_s/240 = 487\text{ mA},$$

or, rounded off upwards, 500 mA.

The circuit should preferably be fitted in a man-made fibre enclosure.

If the output voltage is lower, rather than higher, than the mains voltage, the connections to either the pirmary or the secondary of the additional transformer must be interchanged.

[A. Rietjens - 934058]

NiMH BATTERY CHARGER

Nickel-metal-hydride (NiMH) batteries have now become widely available. A typical one is the 120AAH, which has a capacity of 1.2 Ah in size AA (MN1500; LR6). This type does not lose more than 45% of its capacity through self-discharge over a period of 25 days at a temperature of 20 °C. Recommended fast charging instructions are charging with a current of 0.3C for not more than 2.5 hours, or until the cell voltage has risen to 1.49 V, or until the cell temperature rises above 40 °C. The cell is then charged up to 75% of its capacity, after which it should be charged with a current of 0.1C, which it can stand for long periods. The circuit shown enables these instructions to be adhered to.

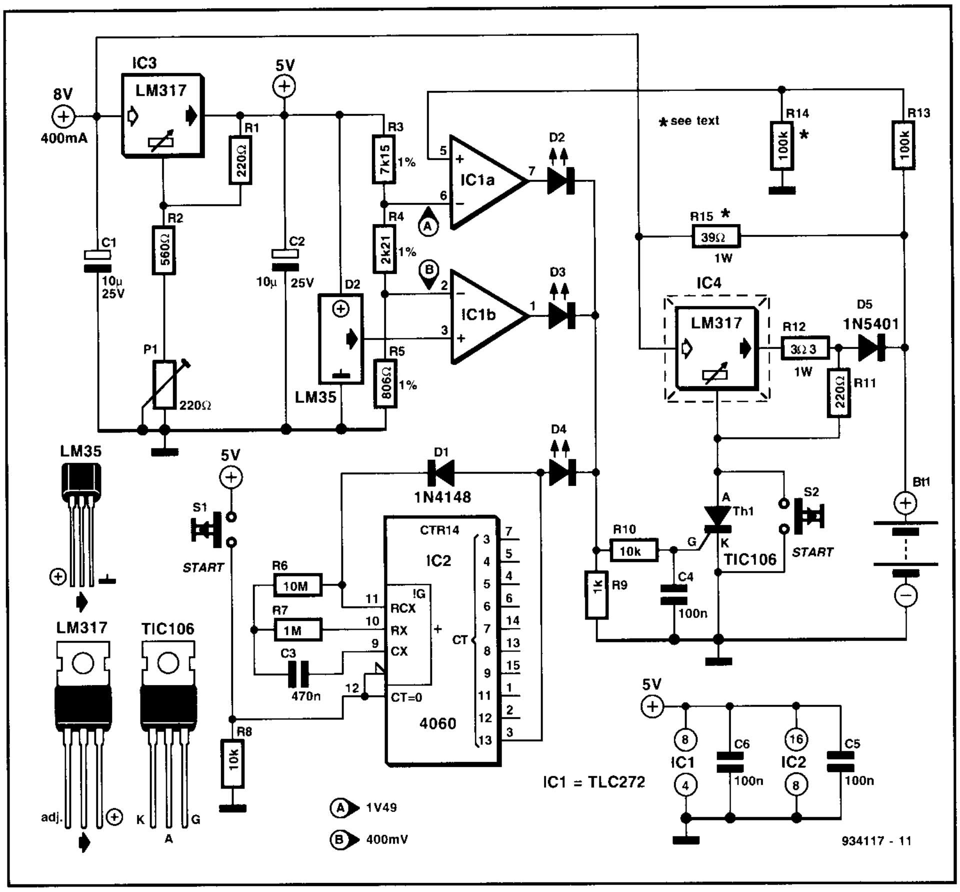
Output CT13 of IC_2 goes high after $2^1/_2$ hours, whereupon charging stops. At the same time, the output of IC_{1a} goes high when the battery voltage rises above 1.49 V per cell. This output then toggles, which also stops the charging.

The number of cells contained in the battery to be charged is set with the value of R_{14}: for 1 cell, the resistor is omitted; its value for 2 cells is 100 kΩ; for 3 cells, 2×100 kΩ in parallel (= 50 kΩ); for 3 cells, 3×100 kΩ in parallel; and so on.

The third way of ending the charging is by means of the temperature measured with IC_5. When the temperature rises above 40 °C, IC_{1b} terminates the charging.

The three charging outputs are formed into OR gates by D_2–D_4. Since these are low-current LEDs, it is immediately visible on what basis charging has been discontinued.

The charger is switched from 0.3 C to 0.1 C (that is, off), te control input of current source IC_4 is connected to earth via thyristor Th_1. The output potential of IC_4 can then not rise above 1.2 V. Since this is lower than the battery voltage, D_5 will be reverse-biased. Further charging of the battery is then via R_{15}. The value of this series resistor (in Ω) is obtained by dividing the difference (in V) between the supply voltage and the battery voltage by 0.12. The quotient should be rounded off to the nearest standard value (the exact value is not terribly important).



The level of the supply voltage depends on the number of cells contained in the battery to be charged. Its minimum value is 4 V plus the number of cells times 1.5 V.

It is necessary to mount IC_4 on a small (10 K W^{-1}) heat sink.

Two keys must be pressed to switch the charger on: S_1 resets timer IC_1 and S_2 switches off thyristor Th_1. These switches could be combined, but double-pole key switches are not generally available.

[K. Walraven - 934117]

BATTERY VOLTAGE MONITOR

Philips' IC Type TEA1041T is intended primarily for monitoring the voltage of 1.8–4.0 V batteries. Internal trigger and timing logic prevent a circuit from reacting to brief breaks in the supply voltage caused by pulses on the load current. One or two LEDs may be used to indicate when the voltage drops below a preset level.

A circuit with two LEDs is shown in **Fig. 1**. Potential divider R_1-R_2 determines the voltage level below which the LEDs indicate that the battery is charged. The divider should give a voltage of exactly 1.25 V at pin 1. Give R_2 a value between 1 kΩ and 100 kΩ and calculate R_1 from

$$R_1 = R_2(U_{th}/1.25-1) \quad [\Omega],$$

where U_{th} is the wanted voltage level. The values of R_3 and R_4 are 100–220 Ω, depending on the battery voltage.

The TEA1041T is enabled when pin 3 is at ground level. If the voltage at pin 1 drops below 1.25 V, a digital counter runs for about 2 s. If the level at pin 1 remains <1.25 V, the IC goes into the alarm state: D_1 lights and continues to do so even when the voltage at pin 1 reaches 1.25 V again. If in this condition S_1 is opened, both LEDs flash for about 4 s. After that, the IC reverts to the standby state, in which it draws a current of about 10 µA, which constitutes only a minute a load on the battery.

Figure 2 shows how the IC can be incorporated in an existing apparatus: D_2 is omitted and pin 3 is permanently at ground level. The monitor is connected across the load as long as S_1 is closed. The IC performs as described earlier, but the LED does not flash after the reset.

If the supply voltage is higher than 4 V,

PROGRAMMER & EMULATOR

The affordable and complete solution for microprocessor development work.

- ☐ Programs and emulates all commonly used eproms 27(C)64 to 27(C)512.
- ☐ A 2764 programmed and verified in 50 secs (seven different algorithms), using 38400 Baud serial comms, download/upload at 3kbytes/second.
- ☐ PC based software includes, basic editor, saving to disk, offset setting, directory & drive setting and controlling programming & emulation.
- ☐ Auto reset of target option at start of emulation.
- ☐ File format conversion utilities and command line version included.
- ☐ 5v. supply only, programming voltages generated by internal SMPSU.

The PROGULATOR: £180 inc.

Further details from:

White House Systems Tel: 091-373-4605

48 South Terrace, Esh Winning, Durham DH7 9PS

MACRO CROSS ASSEMBLERS
for 8051, 6800, 6809, Z80, 6502, ...
with linker and library manager £70

Demonstration
Disc £5.00

B. A. Jones
Freepost (GR1863)
Cheltenham
GLOS. GL50 3BR

Features:-
Conditional assembly,
File inclusion,
Repeated blocks,
Binary/Hex output,
Map files,
Full expression evaluation,
and much more.

Call us now! We have the widest range of components available - At competitive prices!

CABLES
CAPACITORS
VIDEO HEADS
SPEAKERS
CONNECTORS
SEMICONDUCTORS

CRICKLEWOOD ELECTRONICS

Cricklewood Electronics Ltd. 40 Cricklewood Broadway. London NW2 3ET.
Telephone: 081 452 0161 **Faxsimile:081 208 1441**

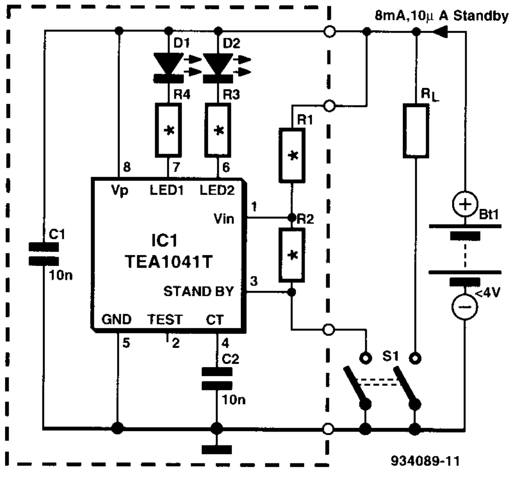
All Major Credit Cards Accepted

connections must be made as shown by the dashed lines in **Fig. 2** (R_1 to R_5 and D_3 and C_3 to earth). The supply voltage is then lowered to 3.3 V by D_3. The potential divider is connected across the full supply voltage.

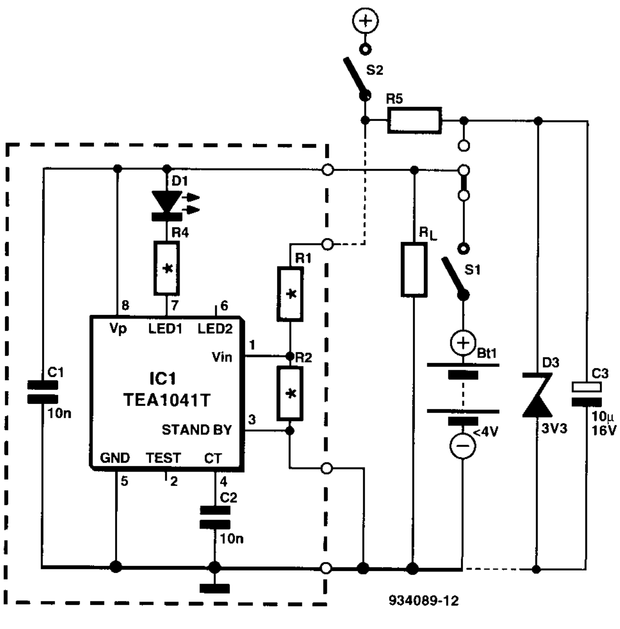
Source: Philips Data Sheet TEA1041T: Battery Low-level Indicator.

[G. Kleine - 934089]

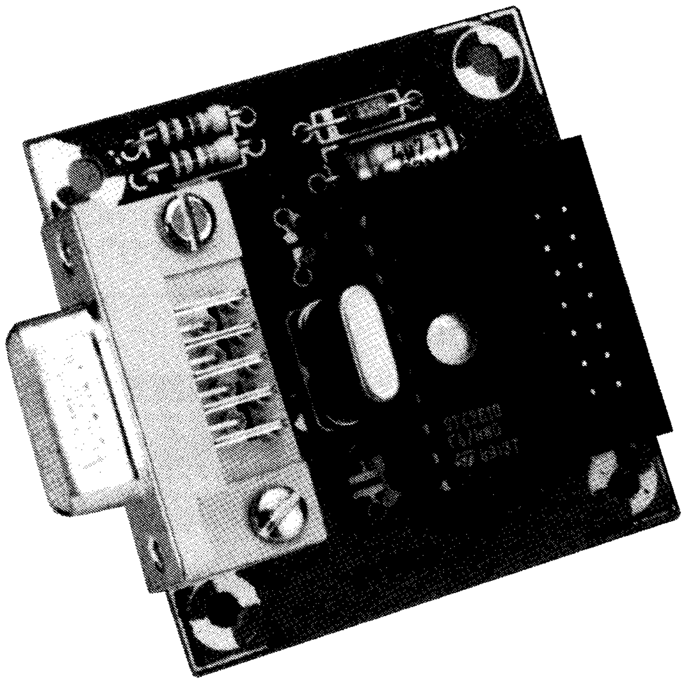
1



2



MICROCONTROLLER-DRIVEN UART



This project demonstrates how a microcontroller fills the bill when it comes to reducing the size and component count of complex digital circuits. Here, one such circuit, the otherwise awesome UART (universal asynchronous receiver/transmitter), is formed by an ST62E10 8-bit controller and a handful of passive parts.

Design by B. Kainka

MANY computer links require serial-to-parallel or parallel-to-series conversion of data formats. Traditionally, this function is performed by a universal asynchronous receiver/transmitter (UART), the best known of which is the AY-3-1015. Unfortunately, this device is not easily programmed from a computer system, since it requires quite a few DIP switches to set up the communication protocol, handshaking, etc. By contrast, the microcontroller used here, an ST62E10 from SGS-Thomson, has a number of registers that allow the PC to use 10 parallel lines as digital inputs or outputs, analogue inputs, or even a mix of these. This 'intelligent' UART is controlled by the PC via the RS232 port, with the registers acting as the software equivalent of DIP switches.

The use of the 20-pin version of the ST62xx microcontroller allows the number of external components to be kept to a minimum, while the current consumption remains limited to a modest 2 mA or so. The extra I/O capacity (8 lines) of the next larger controller in the family, the 28-pin ST62x5, is tempting, but not really required for the present application.

Introducing the ST6210

Considering that it would be too easy, on the one hand, to treat the microcontroller in the circuit as a black box, while, on the other hand, a full description of all the bells and whistles of the device is beyond the scope of this article, a short description is given of the ST6210 architecture, with reference to **Fig. 1**.

The ST62xx family of microcontrollers is based on a so-called macro cell structure, which consists basically of a central unit, ROM or EPROM, RAM, and some peripheral circuitry. The latter comprises:

- a timer with an 8-bit counter and a 7-bit programmable prescaler;
- 8 or 16 digital input/output lines, or analogue input lines;
- a digital watchdog (DWD).

The only difference between the ST621x and the ST622x is the size of the ROM, which is 2 KByte in the ST621x, or 4 KByte in the ST622x. On both controllers, 220 bytes of the ROM space is reserved for the system.

A detailed diagram of the 8-bit core of the ST62xx controller is given in **Fig. 2**. Here, you find the classic ingredients of modern microcontrollers: CPU, ROM, RAM, etc.

The ST62Exx is the family member with EPROM instead of ROM. The advantage of EPROM over conventional ROM is that the memory is erasable and re-programmable, which for the obvious reason of easier debugging, makes it just the thing for application developers. To complete the ST62xx family picture, we should mention the one-time programmable (OTP) version, designated ST62Pxx.

The difference between the 'T' and 'E' version of the ST62xx controller is that two memory areas, 0800H to 087FH, and 0FA0H to 0FEFH, are not usable (reserved) in the 'T' device, while they are available in the 'E' device. In many cases, these 200-odd bytes come in handy to the programmer.

Mixed I/O use is allowed on the microcontroller's port lines, i.e., lines may be programmed individually to function as an input or an output. The input or output function is programmed via the command register contained in the RAM area of the processor. This register is externally programmable, giving full control over all the features offered by the microcontroller. This allows device parameters such as the I/O lines definition, to be held externally (for instance, on a PC), for writing into the ST62xx, while the microcontroller runs a 'fixed' program, reading the parameters from its RAM area as required.

The ST62E10 is connected to a PC via an RS232 link, which keeps the number of I/O lines used down to two. Since the microcontroller proper does not contain an RS232 interface, this function is realized in software, i.e., by appropriate routines that arrange the data transfer to and from the PC.

Port line A0 functions as a the TxD (transmitted data) input, and port line

A1, as the RxD (received data) output. Since the UART we are about to describe belongs functionally in the DTE (data terminal equipment) class, TxD is an input, and RxD, an output.

Circuit description

If you like simple circuits, this one is for you, because the circuit diagram in **Fig. 4** shows only one integrated circuit and seven passive parts. Not surprisingly, this simplicity can be achieved only by a certain amount of 'intelligence' which, you guessed it, resides in the microcontroller. Actually, the intelligence is formed by a chunk of machine code program held in the on-board EPROM.

The microcontroller is clocked by its on-board oscillator, which operates with an external 4-MHz quartz crystal, X1, as the frequency determining component. The controller's port lines are connected to two sockets, K1 for the computer link, and K2 for the parallel equipment. Zener diode D1 keeps the swing of the signal received on port line PA0 within safe limits. Capacitor C1 decouples the microcontroller's supply voltage, while resistors R1 and R2 act as current limiters on the PA0 and PA1 port lines.

It will be noted that the interface does not contain buffers. The baud rate is fixed at 19,200, and determined by the 4-MHz quartz crystal. The baud rate may be doubled to 38.4 Kbaud simply by fitting an 8-MHz quartz crystal. Similarly, a 2-MHz crystal gives a baud rate of 9,600.

Software considerations

Since the microcontroller's clock frequency is divided internally by 13, a maximum of 16 machine cycles is available for each bit. For example, at a clock of 4 MHz:

4,000 kHz / 13 = 307.692 kHz
307.692 kHz / 16 = 19,231 bits/s

Because the length of the processor instructions varies between two and five machine cycles, a bit on the serial link must be recognized or generated in no more than 4 instructions (typically). This means that the programmer can not make use of loops to create serial (RS232) signals. Consequently, each of the 8 bits transmitted has its own set of instructions. Similarly, the instructions that form the 'receive' routine must be in keeping with the chronological order dictated by the 16 machine cycles, irrespective of whether the received information is a 0 or a 1. This is achieved by inserting 'dummy' instructions where necessary. The same goes for the 'transmit' routine.

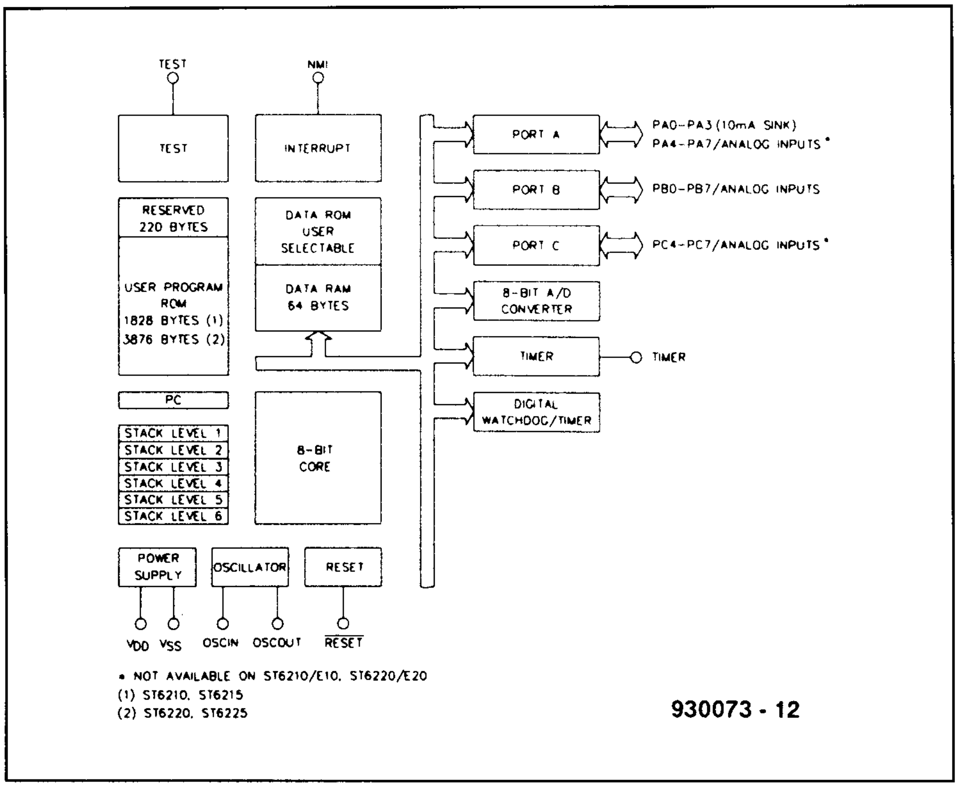


Fig. 1. ST62xx microcontroller family architecture (courtesy SGS-Thomson Microelectronics).

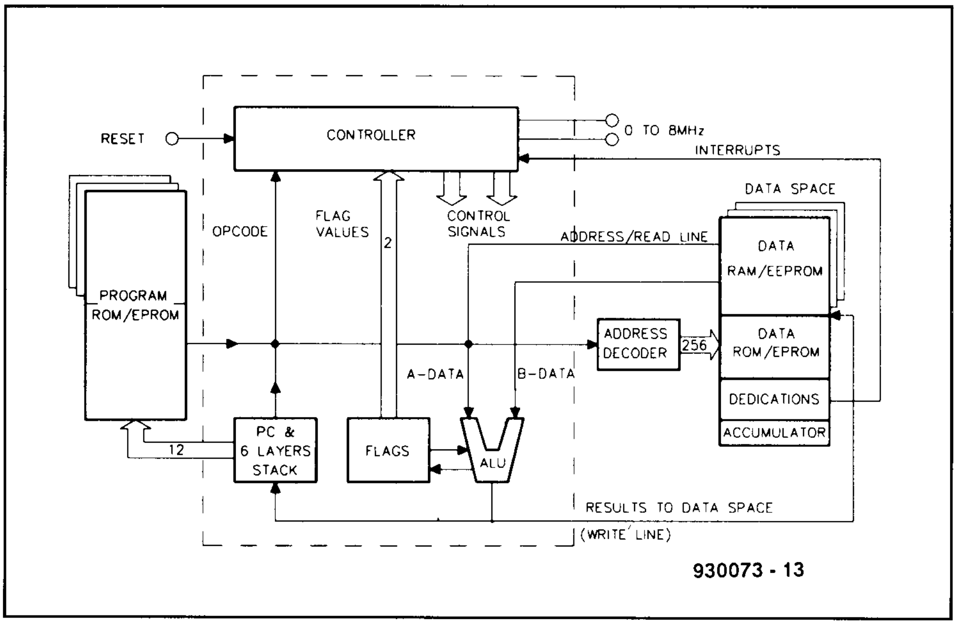


Fig. 2. ST62xx microcontroller core architecture (courtesy SGS-Thomson Microelectronics).

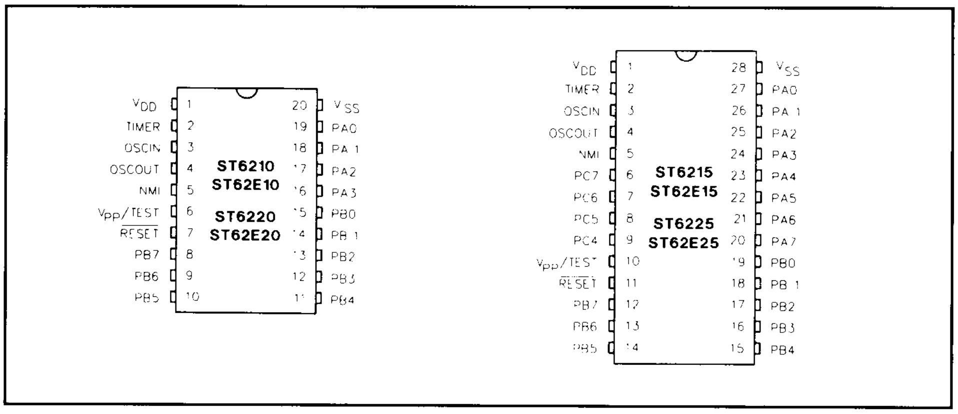


Fig. 3. Pinouts of the devices in the ST62xx family of microcontrollers.

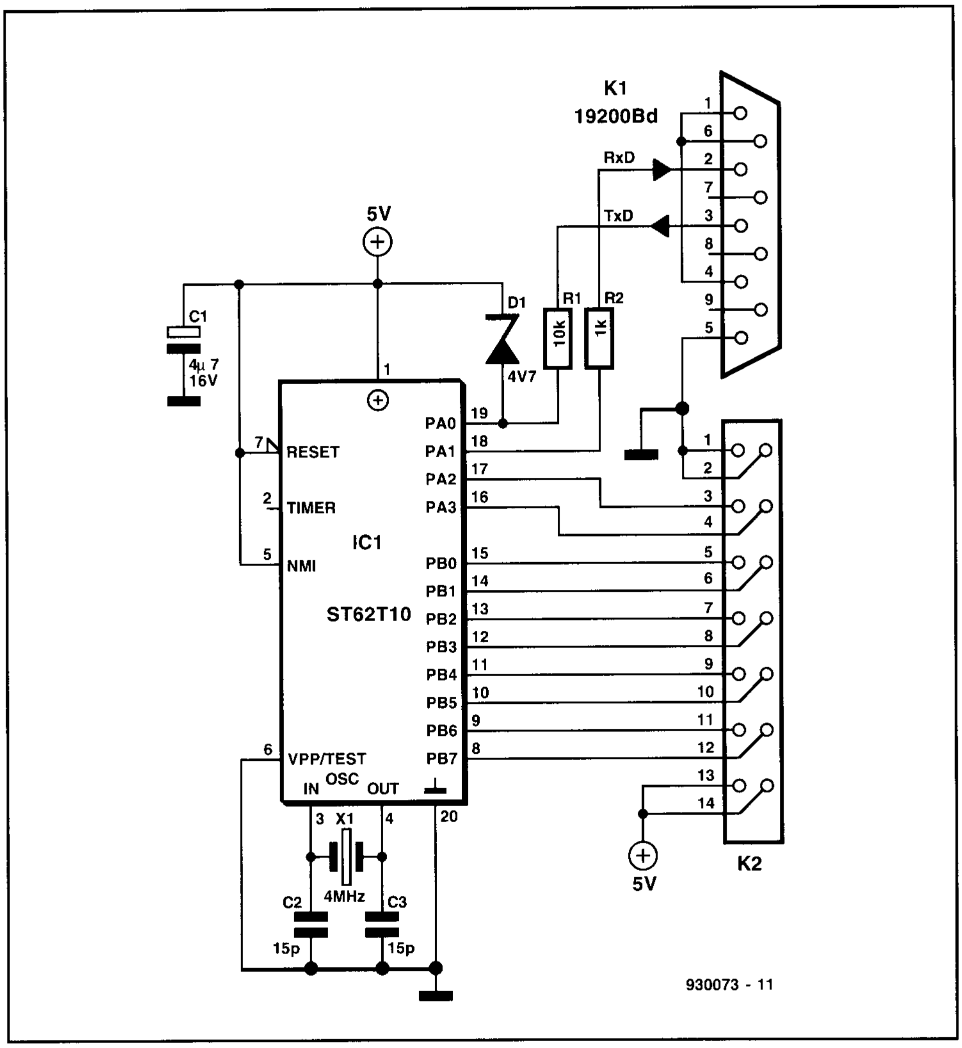


Fig. 4. Circuit diagram of the microcontroller-driven UART.

The main program contains a loop in which data is received, interpreted and processed further. To enable this to be done, the following protocol has been set up: to read the contents of a register, the PC transmits the register address (between 128 and 255), whereupon the microcontroller reads the byte contained at this address, and transmits the information back to the PC. To be able to write to an address, bit 7 must be made 0, i.e. the write addresses of the registers are 0 through 127. The databyte that follows the 'write' address is written into the register. The databyte should come within a certain period after the register 'write' address. If not, the watchdog is alerted, and causes the ST62E10 to be reset.

The interface can be used only if the functions of certain registers in the microcontroller are known. The function of the I/O lines is defined by the following registers: 'ddr' (data direction register), 'ior' (interrupt option register) and 'dr' (data register). Each of the ports A, B and C (ST62x5 only) has its own set of ddr, ior and dr registers. The table below gives the most frequently used options. As already mentioned, each port line can be programmed individually.

ddr	ior	dr	function
0	0	0	input with pull-up
0	0	1	input without pull-up
0	1	1	analogue input, except for PA0-PA3 and PC0-PC3
1	0	x	open-drain output
1	1	x	push-pull output

The microcontroller used in this project is available ready-programmed through our Readers Services under order code 7151.

Interface driver demo

The listing in **Fig. 6** shows a Turbo Pascal program to demonstrate the operation of the UART. The addresses of the most important registers are set up in the 'declarations' preamble of the

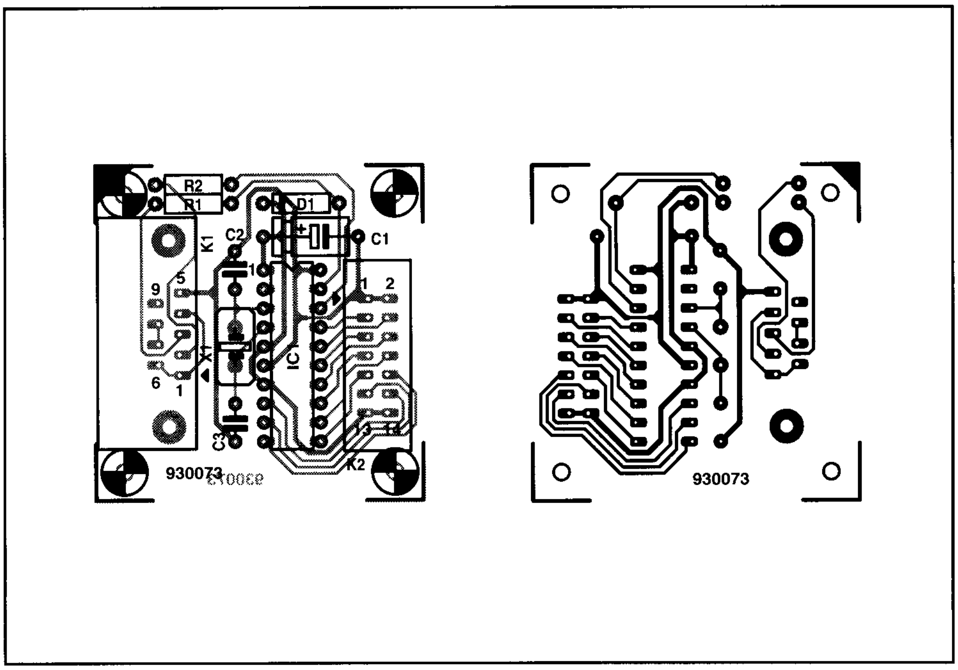


Fig. 5. Artwork for the miniature PCB designed for the UART.

COMPONENTS LIST

Resistors:

1	10kΩ	R1
1	1kΩ	R2

Capacitors:

1	4µF7/16V	C1
1	15pF	C2,C3

Semiconductors:

1	zener 4V7/500mW	D1
1	ST62T10 (order code 7151; see page 110)	IC1

Miscellanaeous:

1	4MHz quartz crystal	X1
1	PCB mount 9-way sub-D socket	K1
1	2x7 pin header	K2
1	Printed circuit board 930073 (see page 110).	

program. The function of each port line must be indicated when the ports are used for digital input or output. Next, it is possible to program a continuous exchange of data between the data register and the relevant port.

To be able to use the analogue-to-digital converter (ADC) contained in the microcontroller, it is necessary to first program one of the port lines as an input. This is achieved via the port register. The actual conversion is started via the ADC command register. The conversion is pretty fast at only 140 µs, after which the result may be read from the ADC data register.

Construction

The artwork of the printed circuit board designed for the microcontroller-driven UART is given in **Fig. 5**. There are very few components to fit, and construction should not present problems. Start by fitting the smaller parts: the resistors, the diode, the crystal (vertically mounted) and the capacitors. Next, mount an IC socket in position IC1, followed by the two connectors.

The UART is connected to the RS232 port on the PC via a 9-way cable. One end of this cable should have a 9-way sub-D plug, the other, a 9-way sub-D socket. The cable should be a 'straight through' type, i.e., no crossed wires for the TxD and RxD pins. If you want to go round making your own cable, go out and buy a so-called Hercules monitor extension cable. These are often cheaper than two 9-way sub-D connectors! ■

```
program st6_Register;
uses Crt    ;
const ddra = $C4;    { direction register a..c }
      ddrb = $C5;
      ddrc = $C6;
      ora  = $CC;    { option register a..c }
      orb  = $CD;
      orc  = $CE;
      dra  = $C0;    { data register a..c }
      drb  = $C1;
      drc  = $C2;
      adcr = $D1;    { A/D control register }
      adr  = $D0;    { A/D data register }

var   N, BA : Integer;

procedure Transmit (charact :Byte);
begin
  while (Port[BA+5] And 32) = 0 do;  { Transmit register empty? }
  Port[BA]:=charact;                 { 32 or 64 or even 96??? }
end;

function Receive :Byte;
var  i :Word;
begin
  i:=0;
  while ((Port[BA+5] And 1)=0) And (i<3200) DO Inc(i);
  if i < 3200
  then Receive:=Port[BA]
  else begin
        Delay(10);
        Receive := 0;
  end;
end;


procedure Init;
var  i :Word;
begin
  BA:=$2F8; { $3F8 = COM1, $2F8 = COM2 }
  Port[BA+3]:=128;
  Port[BA+0]:=6; { 6 for 19200 Baud, 3 for 38400 Baud }
  Port[BA+1]:=0;
  Port[BA+3]:=7; { 8-Bit, n-Parity, 1 Stopbit }
  Port[BA+1]:=0; { no Interrupts }
  Port[BA+4]:=3; { DTR = 1, CTS = 1 }
  i:=Port[BA];     { Input buffer empty }
  Transmit (0);
  Transmit (0);
end;

procedure RegOut (Address,Datum : Byte);
   begin
     Transmit (Address AND 127);
     Transmit (Datum);
   end;

function RegIn (Address : Byte): Byte;
   begin
     Transmit  (Address);
     Regin := Receive;
   end;

{ 1st Example: Transmit and read back digital Data from Port B }

begin
  Init;
  RegOut (ddrb,$FF);    { Port B: Output }
  RegOut (orb,$FF);     { Push-pull }
  repeat
    for n:= 1 to 255 do begin
      RegOut (drb,n);
      if RegIn (drb) <> n then writeln ('Error');
      write (RegIn(drb));
    end;
  until keypressed
end.

{ 2nd Example: Analogue Input to Port B0 }

begin
  Init;
  RegOut (ddrb,$00);    { Port B: Input }
  RegOut (orb,$FF);     { analogue }
  RegOut (drb,$01);     { B0 is present input }
  repeat
    RegOut (adcr,$30);       { Start measuring }
    writeln (RegIn (adr));   { Read measured value }
    delay (100);
  until keypressed
end.
```

Fig. 6. An interface demo written in Turbo Pascal.

FIGURING IT OUT

PART 11 – QUADRIPOLES

By Owen Bishop

This series is intended to help you with the quantitative aspects of electronic design: predicting currents, voltage, waveforms, and other aspects of the behaviour of circuits. Our aim is to provide more than just a collection of rule-of-thumb formulas. We will explain the underlying electronic theory and, whenever appropriate, render some insights into the mathematics involved.

Quadripoles, otherwise known as 4-terminal networks, or 2-port networks, are the final excursion into network analysis in the present series. The essential features of a quadripole are illustrated in **Fig. 90**. The network is linear, its output being directly proportional to its input and varying continuously with it. Current I_1 enters Port 1 by one terminal and leaves by the other. Current I_2 enters and leaves Port 2. The behaviour of the network at any given frequency, and as seen from the outside, may be completely specified by reference to four impedances, known as the **open-circuit** impedance parameters, or **z-parameters**. Current I_1 produces a pd across Port 1 as the result of its flowing through z_{11}. It also produces a pd across Port 2, for which the relevant impedance is z_{21}. Similarly, I_2 produces pds across Ports 1 and 2, as the result of flowing through z_{12} and z_{22} respectively. Summing these pds at each port:

$$U_1 = z_{11}I_1 + z_{12}I_2 \qquad \text{[Eq. 69]}$$
$$U_2 = z_{21}I_1 + z_{22}I_2 \qquad \text{[Eq. 70]}$$

These two equations define the z-parameters. With Port 2 open-circuited, so that $I_2 = 0$, we find:

From Eq. 69: $z_{11} = U_1/I_1$ [Eq. 71]

From Eq. 70: $z_{21} = U_2/I_1$ [Eq. 72]

With Port 1 open-circuited, so that $I_1 = 0$, we find:

From Eq. 69: $z_{12} = U_1/I_2$ [Eq. 73]

From Eq. 70: $z_{22} = U_2/I_2$ [Eq. 74]

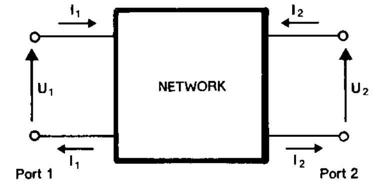


Figure 90

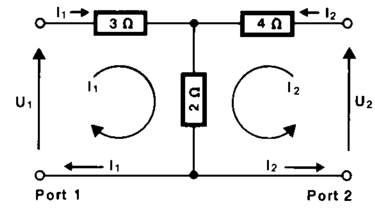


Figure 91

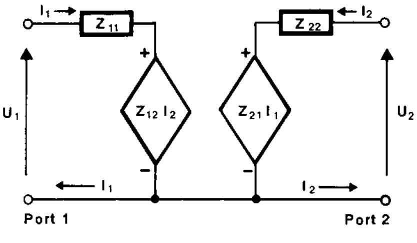


Figure 92

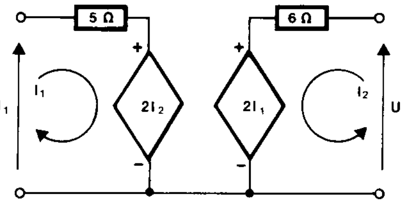


Figure 93

As an illustration, consider the T-section resistance network of **Fig. 91**. Mesh current analysis (Part 4) provides equations from which the z-parameters may be calculated:

Mesh 1: $U_1 = (3+2)I_1 + 2I_2$;
Mesh 2: $U_2 = 2I_1 + 6I_2$.

Note that, instead of defining all currents as clockwise, as we usually do, I_1 is clockwise and I_2 is anticlockwise. This eliminates negatives from the equations. Comparing the coefficients in the mesh equations with those in Eq. 69 and 70, we see that:

$z_{11} = 5\ \Omega$;
$z_{12} = z_{21} = 2\ \Omega$;
$z_{22} = 6\ \Omega$.

All z-parameters are expressed in ohms.

z-parameter model

Based on the z-parameters, a quadripole may be represented by the model of **Fig. 92**. z_{11} and z_{22} are represented as impedances in series with the ports. U_1, the pd produced at Port 1 as a result of I_2, is represented by a **controlled voltage source**, $z_{12}I_2$, accounting for the last term of Eq. 69. Similarly, the last term of Eq. 70 is represented by the controlled voltage source $z_{21}I_1$. **Figure 93** shows the T-network of **Fig. 91** as a z-parameter model. This model can be used to predict the behaviour of the network when connected to external circuits. If we know the voltages at the ports, we use Eq. 69 and 70 to calculate the currents. Conversely, given the currents, we can calculate the voltages.

Example. In the network of **Fig. 91**, $I_1 = 2$ A, $I_2 = 3$ A. Calculate U_1 and U_2.

From Eq. 69:
$U_1 = 5 \times 2 + 2 \times 3 = 16$ V.

From Eq. 70:
$U_2 = 2 \times 2 + 6 \times 3 = 22$ V.

Determining parameters

If the circuit of the quadripole is known, z-parameters may be calculated by the usual network techniques, as we did for **Fig. 91**. These are open-circuit parameters, which means that the ports can be considered in turn as open circuits to simplify the calculations. As an example, take the π-network of **Fig. 94**. With Port 2 open-circuited, I_2 flows through R_1 in parallel with R_3 and R_2. Their combined resistance is 4.167 Ω. From Eq. 71:

$$z_{11} = U_1/I_1 = 4.167\ \Omega.$$

The current flowing through R_2 is:

$$I_R = I_1 \times R_1/(R_1 + R_2 + R_3)$$

$$= 5I_1 / 30 = I_1 / 6.$$

This generates a pd across R_2:

$$U_2 = 15I_1 / 6 = 2.5I_1.$$

Now we can calculate z_{21}, using Eq. 72:

$$z_{21} = U_2 / I_1 = 2.5\ \Omega.$$

With Port 1 open-circuited, similar calculations show that:

$$z_{12} = 2.5\ \Omega;$$
$$z_{22} = 7.5\ \Omega.$$

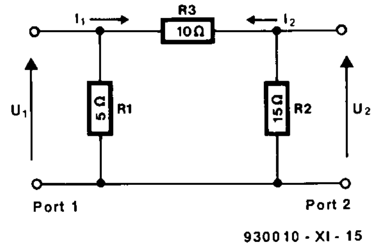


Figure 94

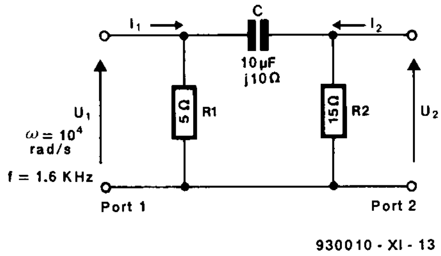


Figure 95 a

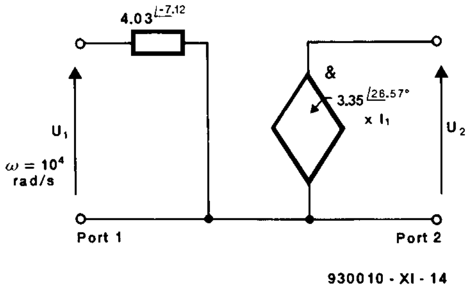


Figure 95b

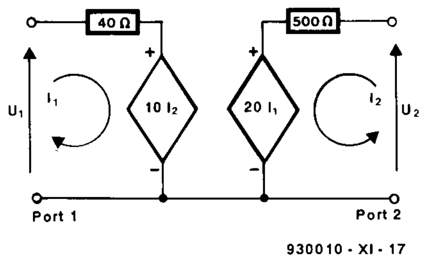


Figure 96

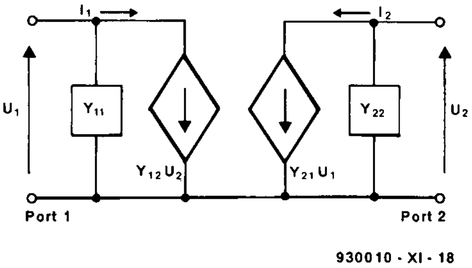


Figure 97

Now suppose that R_3 is replaced by a 10 µF capacitor (**Fig. 96a**). If $\omega = 10^4$, then $X_C = -1 / \mathbf{j}\omega C = -\mathbf{j}10\ \Omega$. We can use this in place of the resistance of R_3 in the calculations above. The combined impedance of R_2 and X_C is $(15 - \mathbf{j}10)\ \Omega$. In parallel with 5 Ω, the total resistance is

$$5\,(15 - \mathbf{j}10) / (5 + 15 - \mathbf{j}10)$$
$$= (15 - \mathbf{j}10) / (4 - \mathbf{j}2)$$
$$= 18.03 \angle{-33.69°} / 4.47 \angle{-26.57°}$$
$$= 4.03 \angle{-7.12°}.$$
$$z_{11} = 4.03 \angle{-7.12°}\ \Omega.$$

Techniques for handling complex numbers are described in Part 8.

Current flowing through R_2 is:

$$I_R = I_1 \times 5 / (20 - \mathbf{j}10).$$

The pd across R_2 is:

$$U_2 = I_R R_2 = 75I_1 / (20 - \mathbf{j}10)$$
$$= I_1 \times 75 / 22.36 \angle{-26.57°}$$

$$\therefore\ z_{21} = U_2 / I_1$$
$$= 75 / 22.36 \angle{-26.57°}$$
$$= 3.35 \angle 26.57°\ \Omega.$$

From these two parameters we can calculate the gain of this network, assming that it is lightly loaded. With a high-impedance load, $I_2 \approx 0$.

The Port 1 voltage source, $z_{12}I_2$, and z_{22} may be omitted from the model (**Fig. 95b**). Then, from Eq. 69 and 70:

$$\text{gain} = U_2 / U_1 = z_{21} / z_{11}$$
$$= 3.35 \angle 26.57° / 4.03 \angle{-7.12°}$$
$$= 0.83 \angle 33.69°.$$

The output pd is 0.83 times the input pd and there is a phase lead of 33.69°.

Repeating this calculation with $\omega = 2 \times 10^4$ gives a gain of $0.95 \angle 18.43°$. Gain is increased and phase lead is reduced, as might be expected with a high-pass filter network.

Practical technique

The z-parameters of a complicated network may be measured indirectly. By leaving the appropriate port open-circuit, we can make either I_1 or I_2 equal to zero. Then, measurements of the other current and the voltage are substituted in Eq. 71–74. Once these values are obtained, we use them to predict the behaviour of the quadripole under other input and output conditions.

Example. At a given frequency, and with Port 2 open-circuited (so that $I_2 = 0$) and 10 V applied to Port 1, measurements made on an unknown network are:

$U_1 = 10$ V;
$U_2 = 5$ V;
$I_1 = 0.25$ A.

With Port 1 open-circuited (so that $I_1 = 0$) and 10 V applied to Port 2, measurements made are:

$U_1 = 0.2$ V;
$U_2 = 10$ V;
$I_2 = 0.02$ A.

With Port 2 open-circuited, substituting in Eq. 69 and solving for z_{11}:

$$z_{11} = 10 / 0.25 = 40\ \Omega.$$

Substituting in Eq. 70 and solving for z_{21}:

$$z_{21} = 5.0 / 25 = 20\ \Omega.$$

Similarly, with Port 1 open-circuited:

$$z_{12} = 0.2 / 0.02 = 10\ \Omega;$$
$$z_{22} = 10 / 0.02 = 500\ \Omega.$$

Figure 96 shows these results incorporated in the z-parameter model. The parameters may now be used to predict network behaviour with other values of pd or current at the same frequency.

Other parameters

The z-parameters show how the voltages are determined by the currents and impedances as defined in Eq. 69 and 70. We can write a corresponding pair of equations showing how the currents are determined by the voltages and another set of parameters, the y-parameters. This is another instance of duals (see Part 5), so it should come as no surprise to find that the y-parameter model of a quadripole has an **admittance** in **parallel** with each port, and a pair of controlled **current** sources (**Fig. 97**). As might be expected from the duality, y-parameters are calculated or measured by **short-circuiting** one or the other of the ports. The equations for y-parameters are:

$$I_1 = y_{11}U_1 + y_{12}U_2;$$
$$I_2 = y_{21}U_1 + y_{22}U_2.$$

The y-parameters are admittances, so their unit is the siemens (S). They are used in calculations similar to those above, if working with admittances is more convenient.

A third set of parameters consists of the h-parameters. The h stands for 'hybrid', because these parameters are based on a mix of U_1 and I_2, the **pd** across Port 1 and the **current** through Port 2:

$$U_1 = h_{11}I_1 + h_{12}U_2 \quad \text{[Eq. 75]}$$
$$I_2 = h_{21}I_1 + h_{22}U_2 \quad \text{[Eq. 76]}$$

We will find the h-parameters for the circuit of **Fig. 91**. With Port 2 short-circuited, as in **Fig. 98a**, (so that $U_2 = 0$), from Eq. 75:

$$h_{11} = U_1 / I_1.$$

But U_1 / I_1 equals the resistance of the network when Port 2 is short-circuited: this is 3 Ω in series with 2 Ω and 4 Ω in parallel. This gives a total resistance of 4.33 Ω. Thus, h_{11} = 4.33 Ω. The unit of h_{11} is ohms.

From Eq. 76, we have:

$$h_{21} = I_2 / I_1.$$

Figure 98b shows the shorted network redrawn to make flow of current easier to visualise. The pd across AB is:

$$U = 2(I_1 + I_2) = -4I_2;$$
$$\therefore\ I_1 = -3I_2.$$

Substituting in the equation for h_{21}:

$$h_{21} = -1 / 3.$$

h_{21} is a ratio between two currents: it is a pure number without units.

With Port 1 **open-circuited**, as in **Fig. 91**, so that $I_1 = 0$, we have from Eq. 75:

$$h_{12} = U_1 / U_2 = 2 / 6 = 1 / 3.$$

Here, the 4-ohm and 2-ohm resistors act as a potential divider, and U_2 is divided by 3 to provide U_1. Again, this is a ratio with no units.

From Eq. 76:

$$h_{22} = I_2 / U_2 = 1 / 6 \text{ S}.$$

This is the admittance of the 4-ohm and 2-ohm resistors in series; its unit is the siemens.

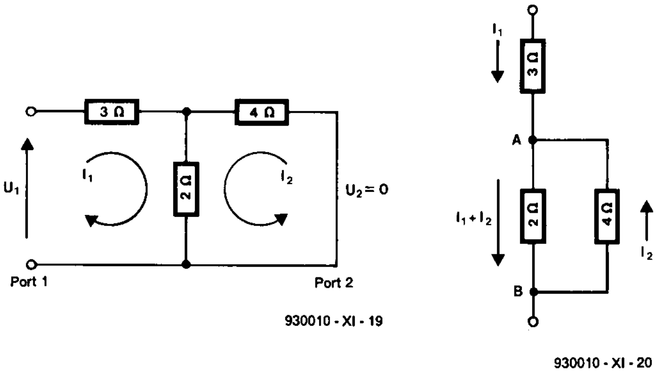


Figure 98

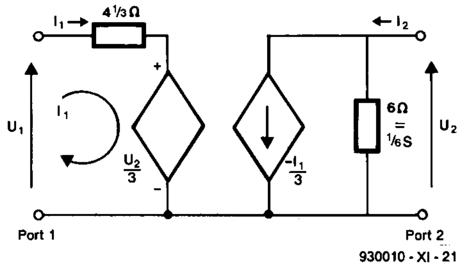


Figure 99

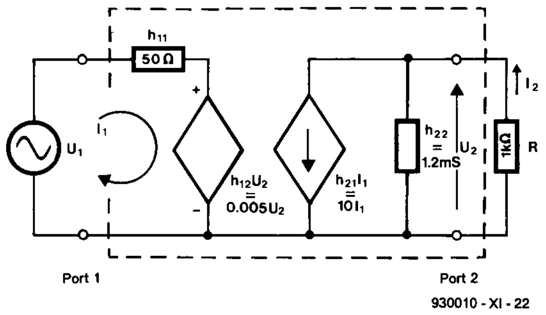


Figure 100

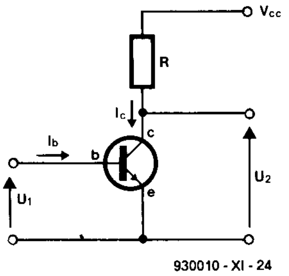


Figure 101 a

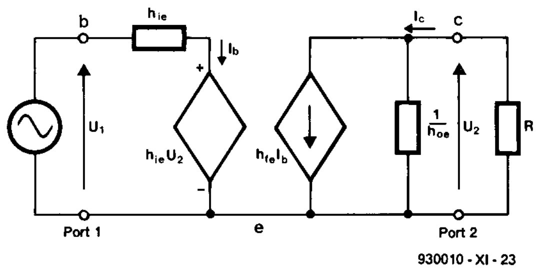


Figure 101 b

We now have all the parameters and can set up the model (**Fig. 99**). Use this to make predictions. For example, evaluate the currents if U_1 = 10 V and U_2 = 5 V. On the Port 1 side, the current through the resistor is the result of the pd across it, which is:

$$10 - h_{12}U_2 = 10 - U_2 / 3$$
$$= 10 - 5 / 3 = 8.333$$

$$\therefore\ I_1 = 8.333 / 4.333 = 1.923 \text{ A.}$$

On the Port 2 side, the current through the 6-ohm resistor (equivalent to 1/6 S admittance) is 5/6 A. The current from the controlled source is $-I_1 / 3 = -1.923 / 3 = -0.641$ A. I_2 equals the current through the 6-ohm resistor **plus** the current produced by the source, which, being negative, flows in the opposite direction to the arrow:

$$I_2 = 5 / 6 - 0.641 = 0.1923 \text{ A.}$$

The current gain of this network is $I_2 / I_1 = 0.1$.

This simple example has the merit that its results can be checked easily by mesh analysis of **Fig. 91**, with applied voltages of 10 V and 5 V. The reader may care to work this as an exercise, and confirm that the h-parameter technique gives the correct results.

Extending *h*-parameters

Consider the model of **Fig. 100**, the circuit details of which are not relevant for the moment. It receives input U_1 from a variable pd source and its output U_2 is fed to load resistor R. The h-parameters are marked on the figure. By Ohm's law:

$$I_2 = -U_2 / R = -U_2 / 1000 \quad \text{[Eq. 77]}$$

Also, from Eq. 76:

$$I_2 = h_{21}I_1 + h_{22}U_2$$
$$= 10I_2 + 0.0012U_2.$$

Substituting the value of I_2 from Eq. 77:

$$-U_2 / 1000 = 10I_2 + 0.0012U_2$$

$$\therefore\ I_1 = -(0.0012U_2 + U_2/1000)/10$$
$$= -U_2\,(0.0012 + 0.001) / 10$$
$$= -U_2\,(0.0022) / 10$$
$$= -0.00022U_2.$$

Substituting this value and the values of the h-parameters in Eq. 75:

$$U_1 = -0.00022U_2h_{11} + h_{12}U_2$$
$$= -0.00022U_2 \times 50 + 0.005U_2.$$
$$\therefore\ U_1 / U_2 = -0.011 + 0.005$$
$$= -0.006.$$

The pd gain of the network is the reciprocal of this:

$$U_2 / U_1 = -1 / 0.006 = -167.$$

That is, **the pd gain is -167.** The network is an inverting voltage amplifier. It has the features of a common-emitter amplifier based on an n-p-n bipolar junction transistor (**Fig. 101a**). In the figure we show a pd source U, but omit biasing resistors, which can be considered to be part of the pd source. Comparing the two parts of this figure, we see that I_1 is the base current I_b, while I_2 is the collector current, I_c. The h-parameters are given special subscripts to relate them to the operation of the transistor:

h_{11} becomes h_{ie}, the input resistance;
h_{21} becomes h_{fe}, the forward current ratio, or gain;
h_{12} becomes h_{re}, the reverse feedback voltage ratio;
h_{22} becomes h_{oe}, the output admittance.

The 'e' in each subscript refers to the fact that the transistor is in the common-emitter configuration. Each of these parameters is measurable for a given transistor, or can be obtained from a data sheet. h_{ie} and h_{fe} are measured with the transistor output short-circuited; h_{re} and h_{oe} are measured with an open-circuit input. Given these parameters, the behaviour of the amplifier can be predicted, provided that it is operating in the linear part of its range, and with small signals.

The values of h_{re} and h_{oe} for most transistors allow some simplification of the model. **Figure 102** shows a common-emitter amplifier with typical values for the h-parameters. We have omitted the controlled voltage source, because h_{re} is typically only 0.0001, with the result that the voltage source can usually be ignored. R is the load resistor in the collector circuit. In the model, we are specifying that the controlled current source is drawing the collector current through that resistor, ultimately from the negaive rail through the low impedance of the power supply. We can say this because the collector current is virtually independent of supply voltage. The current is split between h_{oe} and R, which are in parallel. By the rules of current division:

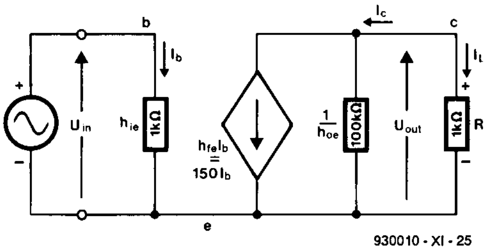


Figure 102

$$I_L = -h_{fe}I_b \times \frac{1/h_{oe}}{1/h_{oe}+R}$$

$$= -h_{fe}I_b / (1 + h_{oe}R).$$

Current gain is

$$I_L / I_B = -h_{fe} / (1 + h_{oe}R_L)) \qquad \text{[Eq. 78]}$$

Given the values of **Fig. 102** ($h_{oe} = 10^{-5}$), the current gain is

$$-150 / (1 + 10^{-5} \times 10^3)$$
$$= -150 / 1.01 = -148.5.$$

This is a large current gain, as is typical of a common-emitter amplifier. The negative sign indicates that it is 180° out of phase with the input signal.

In practice, it is reasonable to simplify the model further without undue loss of precision. The output admittance is small (only a few microsiemens), so h_{oe} can usually be omitted, too. Given that h_{oe} is very small, the term $h_{oe}R$ can be omitted from Eq. 78, so that

$$\text{current gain} \approx -h_{fe} = -150.$$

Other characteristics of the amplifier are calculated in a similar way by making suitable assumptions and analysing the network with the use of techniques described in previous parts. Equations may become involved, but the mathematics is simple. For example, to calculate voltage gain, we first consider the left-hand mesh of **Fig. 102**:

$$U_{in} = h_{ie}I_b.$$

In the right-hand mesh, ignoring h_{oe}:

$$U_{out} = -h_{fe}I_bR.$$

$$\text{Voltage gain} = U_{out} / U_{in}$$
$$= -h_{fe}I_bR / h_{ie}I_b$$
$$= -h_{fe}R / h_{ie}.$$

In **Fig. 102**, the voltage gain is

$$(-150 \times 10^3) / 10^3 = -150.$$

The output signal is 180° out of phase with the input signal.

Other amplifiers

The models for common-base and common-collector amplifiers have the same layout as that of the common-emitter amplifier. The subscripts on the parameters end in 'b' or 'c', but otherwise the diagrams are the same. The typical values of the parameters are not necessarily the same as in the common-emitter model. For example, the absolute value of h_{fb} is a little less than unity, typically −0.99. Together with the fact that h_{ob} is exceedingly low (a few hundred nanosiemens, equivalent to over 1 MΩ), this means that current gain is very slightly less than 1 in any practical common-base amplifier. Also, since h_{fb} is negative, the output signal is in phase with the input signal. Typically, h_{ib} is small, around 20–30 Ω.

In the common-collector (emitter-follower) model, h_{ic} is large (1 kΩ or more), and h_{fc} is typically −100, giving large current gain with no phase shift (one of the main purposes of using a c-c amplifier). h_{rc} is 1, giving unity voltage gain, as required in an emitter follower, while h_{oc} has a moderate value.

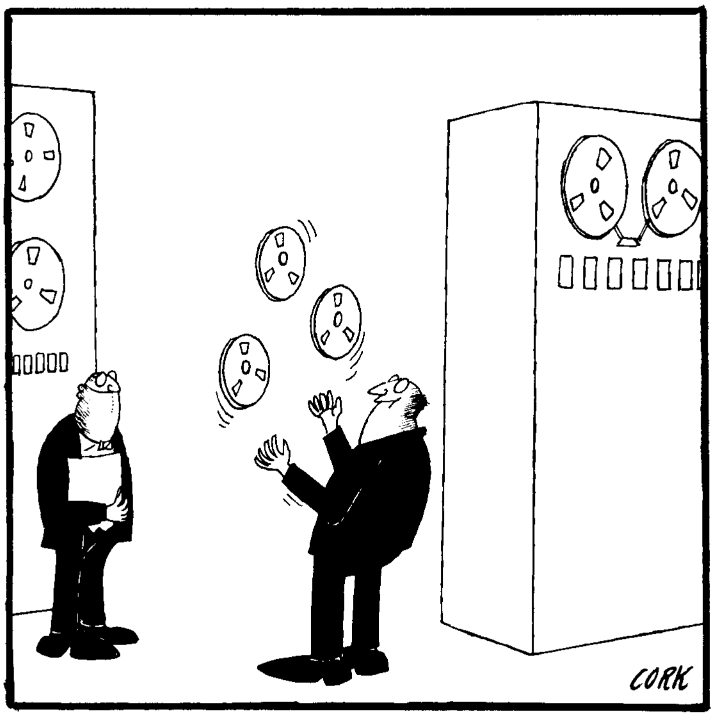
TO BE CONTINUED

Test yourself

1. Calculate the z-parameters for **Fig. 91**, given $R_1 = 10\ \Omega$, $R_2 = 14\ \Omega$ and $R_3 = 6\ \Omega$.
2. Calculate z_{11} and z_{21} for **Fig. 95a**, given that $R_1 = 10\ \Omega$, $R_2 = 12\ \Omega$, $C = 1\ \mu F$ and $\omega = 10^4$ rad/s. What is the voltage gain of this network?
3. In an unknown quadripole circuit, $U_1 = 1$ V, $U_2 = 3$ V, $I_1 = 20\ \mu A$ and $I_2 = 2.5$ mA. Calculate the h-parameters.

Answers to Test yourself (Part 10)

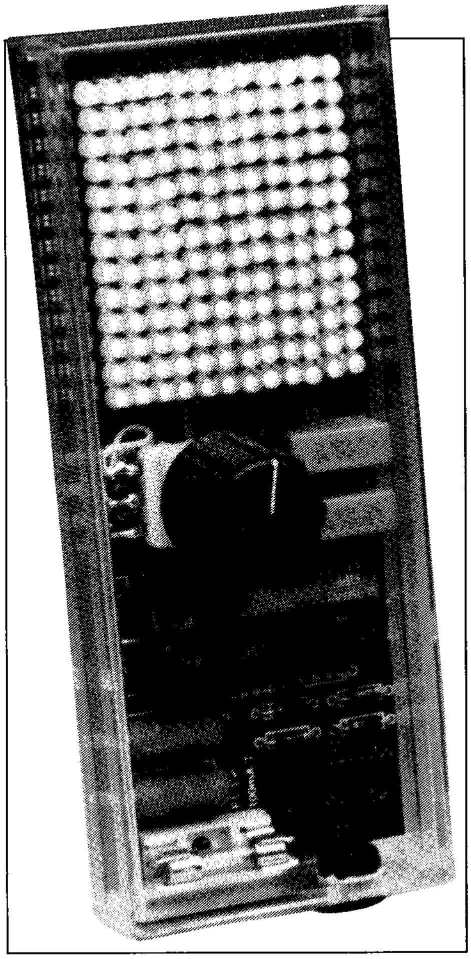
1. $I_1 = 0.56$ A; $I_2 = 0.04$ A; $I_3 = 0.32$ A. In 3 Ω: 0.9408 W; in 2 Ω: 0.0032 W; in 4 Ω: 1.0816 W; in 1 Ω: 0.0576 W; in 7 Ω: 0.7168 W. 4 V source: 2.24 W; 2 V source: 0.56 W. Total for resistors = total for sources = 2.8 W.
2. 40 W.
3. (a) 0.547 W; (b) 0 W.
4. 1.627 mW.
5. 12 mW.
6. $X_L = j6$; $X_C = -j6$. Power factor = 0.944.



PHOTOGRAPHIC WORKSHOP LIGHT

This article describes a low-cost alternative to the normally pretty expensive lamp used to light the photographic darkroom. It consists of an array of yellow LEDs (light-emitting diodes), which emit a wavelength to which (colour) photographic paper is highly insensitive.

Design by F. Stolpe



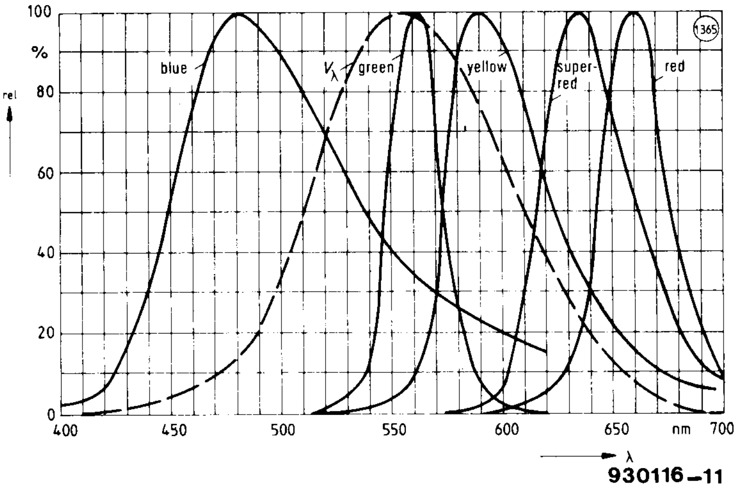


Fig. 1. Light spectrum as emitted by different colour LEDs (source: *Siemens Optoelectronics Databook 1990*).

As far back as the days of black-and-white photography, photographic paper was already made insensitive to light of a certain colour. This was done to enable the photographer to see what he was doing in the darkroom while taking the photographic prints through the developing process. The colour red was chosen, and a normal bulb was painted red because the exact colour was not so important. With the introduction of colour photography things became a little more difficult, because the photographic paper has to be sensitive to all colours in the visible spectrum. None the less, this type of paper has been made insensitive to one specific colour, of which the wavelength is fairly accurately defined between 580 nm and 600 nm (nm = nanometres; 10^{-9} metres). This wavelength was chosen because a special type of sodium lamp has two spectral lines in this range, one at 588.99 nm, and one at 589.59 nm. The disadvantage of this lamp is its rather high price. Less expensive alternatives to the sodium lamp are normal bulbs with a narrow-band filter. Unfortunately, these lamps still cost well over £20.

The wavelength of light emitted by yellow LEDs is typically around 590 nm (see **Fig. 1**). The spectrum of the LED lamp is not as narrow as that of a sodium lamp, but that is of little consequence since this disadvantage also applies to the filter lamp. The width of the spectrum emitted by a yellow LED depends on the type and manufacturer. That is why you have to do an exposure test using the LED lamp and a sample strip of photographic paper to make sure that the lamp has no effect on the paper (see further on in this article).

Another problem is the low light intensity produced by an LED (10 to 20 milli-candela for normal LEDs, and about 100 milli-candela for high-efficiency LEDs). Fortunately, this problem is simple to solve by using a large number of LEDs.

The LED lamp

Obviously, to keep the cost of the LED lamp below that of a ready-made lamp, the number of components used (apart from the LEDs) must be kept as small as possible. Also, the design should be based on commonly available, inexpensive parts. With this in mind, it will not come as a surprise that a mains transformer has been omitted from the design. As shown by the circuit diagram in **Fig. 2**, it is possible to use the rectified mains voltage if a maximum of 156 LEDs are connected in series. The number of LEDs to be connected in series is determined by their colour and maximum forward voltage drop (see **Table 1**). Here, the darkroom demands yellow LEDs; the other colours given in the table are for different applications, of which more further on.

As already mentioned, the LEDs are supplied directly from the mains voltage, which means that you have to pay special attention to insulation and safety. The mains voltage (live and neutral) is connected to PCB terminal block K1, and arrives at a bridge rectifier, D1-D4, via fuse F1. The circuit is connected to the mains via a PCB

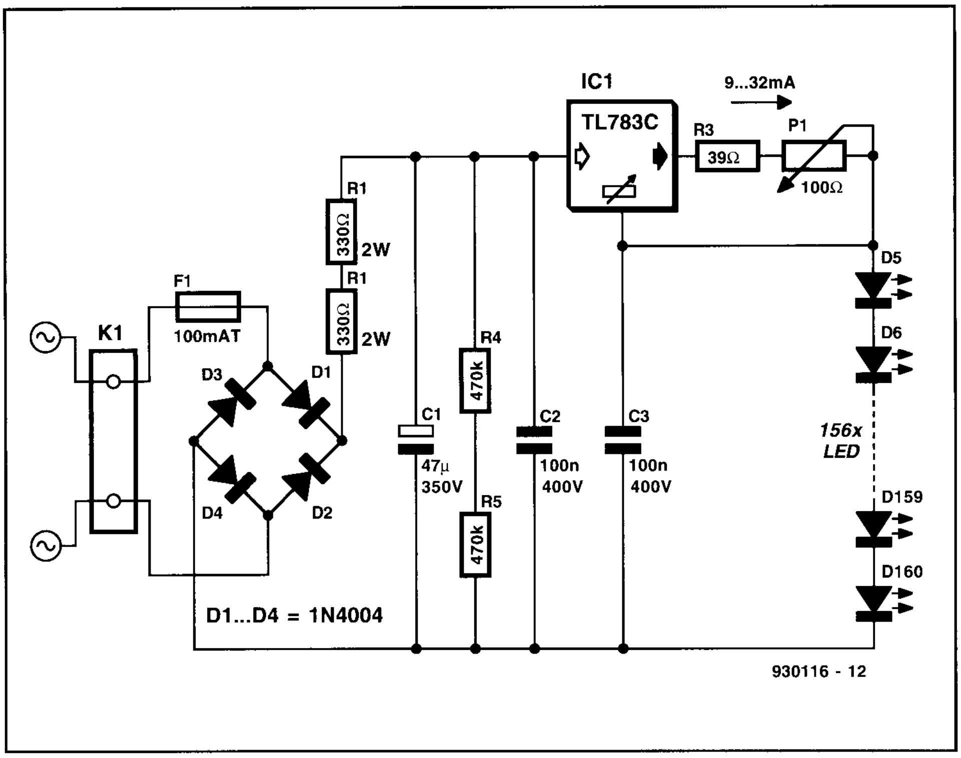


Fig. 2. The circuit diagram is simplicity itself: a rectifier, a current source and LEDs, lots of LEDs.

mount terminal block because that is the simplest way of connecting the mains cable in a safe manner. The fuse automatically removes the mains voltage from the circuit in the event of a fault, thus eliminating a fire risk. Resistors R1 and R2 limit the power-on surge current through C1 to about 0.5 A. This is done to prevent unnecessary burning out of the fuse. The voltage across C1 is about 335 V, which equals the peak value of the mains voltage (240 V_{rms} in the UK). The smoothing capacitor, C1, is shunted by resistors R4 and R5, which remove the capacitor's charge in a few seconds after the lamp is switched off. Of course, the LEDs also help to do this, but R4 and R5 ensure that no dangerous voltage remains across C1 when the circuit is switched off. R4 and R5 may **not** be replaced by a single 1-MΩ resistor. This is because most small resistors (0.25-W and 0.33-W types) are rated to only 200 V, which is too low for the 335 V which exists across C1. By connecting two identical resistors in series, the voltage across C1 is distributed equally, so that it is possible to use two ordinary low-power resistors.

Colour	Forward drop typ.	max.	Max. number
yellow	2.2	2.6	130
green	2.2	2.6	130
red	1.6	2	156
blue	4	8	65
IR	1.5	2	156

Table 1. Forward voltage of different types of LED, and the maximum number that may be accommodated on the printed circuit board.

Voltage regulator IC1 is connected as a current source. This is based on the tendency of the device to maintain a voltage difference of 1.25-V between its control input and output. Consequently, the voltage across R3 and P1 is always 1.25 V. The indicated values of R3 and P1 allow the current drawn by the LEDs to be set to a value between 9 mA and 32 mA with the aid of P1.

Since IC1 keeps the current through the LEDs constant, variations of the mains voltage and/or the forward voltage of the LEDs have no effect on the light intensity produced by the lamp. It does, however, affect the voltage across IC1. In particular, the voltage drop across the LEDs is a considerable factor, which is not surprising in view of the number of LEDs used. A deviation of 0.1 V per LED, for instance, gives a total error of more than 10 V. Such deviations are quite common, see the data in **Table 1**. Moreover, the voltage across IC1 varies appreciably as a function of the lamp intensity setting (with P1). To prevent this from causing an overload condition in the regulator, a TL783C is used instead of the perhaps more familiar LM317. The TL783C is capable of withstanding a voltage difference of 125 V between its input and output. By comparison, the 35 V specification of the LM317 is on the low side for this application.

Construction

The artwork designed for the printed circuit board used to build the LED lamp is shown in **Fig. 3**. To be able to fit the board into the transparent plastic enclosure stated in the parts list, notches have to be cut in the edges, at about the height of C1. Also, a rectangular clearance has to be cut in which C1 is seated. This reduces the mounting height of C1, and enables the enclosure to be shut. The mains cable is fitted with a strain relief clamp at the inside of the enclosure.

The LEDs

Each number of LEDs given in **Table 1** is rounded off to a multiple of 13 so that only whole rows of LEDs are fitted on to the board. Non-used rows must be bridged start-to-end by a wire. If you want to fit as many LEDs as possible, make sure that the voltage drop across the LED array remains below 290 V.

If you mount fewer LEDs, the voltage across IC1 rises. To prevent the voltage drop exceeding 125 V, the voltage across the LEDs may not drop below 210 V. With some colours, the maximum number of LEDs that can be fitted on to the PCB (156) is given, instead of the number the circuit would be capable of driving. If you choose not to build the circuit on the indicated printed circuit board, the actual maximum number of LEDs that may be used is fairly simple to calculate.

The circuit is, in principle, designed for yellow LEDs. When another colour is used, the number of LEDs that can be fitted changes, as indicated in **Table 1**. Note, however, that the current supplied by IC1 is geared to 'normal' LEDs — by contrast, the maximum current that may be used for low-power or high-efficiency LEDs is much lower. In that case, R3 and P1 must be changed (I=1.25/(R3+P1)). The reverse applies to infra-red LEDs, which require a higher current (typically around 100 mA).

The above goes to show that the circuit is eminently suited to driving all kinds of LED. Before choosing a particular colour and type, however, it is wise to check its typical operating current, and the voltage drop at different currents.

Apart from a darkroom light, there are a number of other applications of the LED lamp. Many possibilities are created just by changing the shape of the LED array. Infra-red LEDs allow the lamp to be used as a spotlight for infra-red photography, or to assist a CCD (charge-coupled device) camera when making pictures or recordings in the dark, for instance, of animals which are active during the night only.

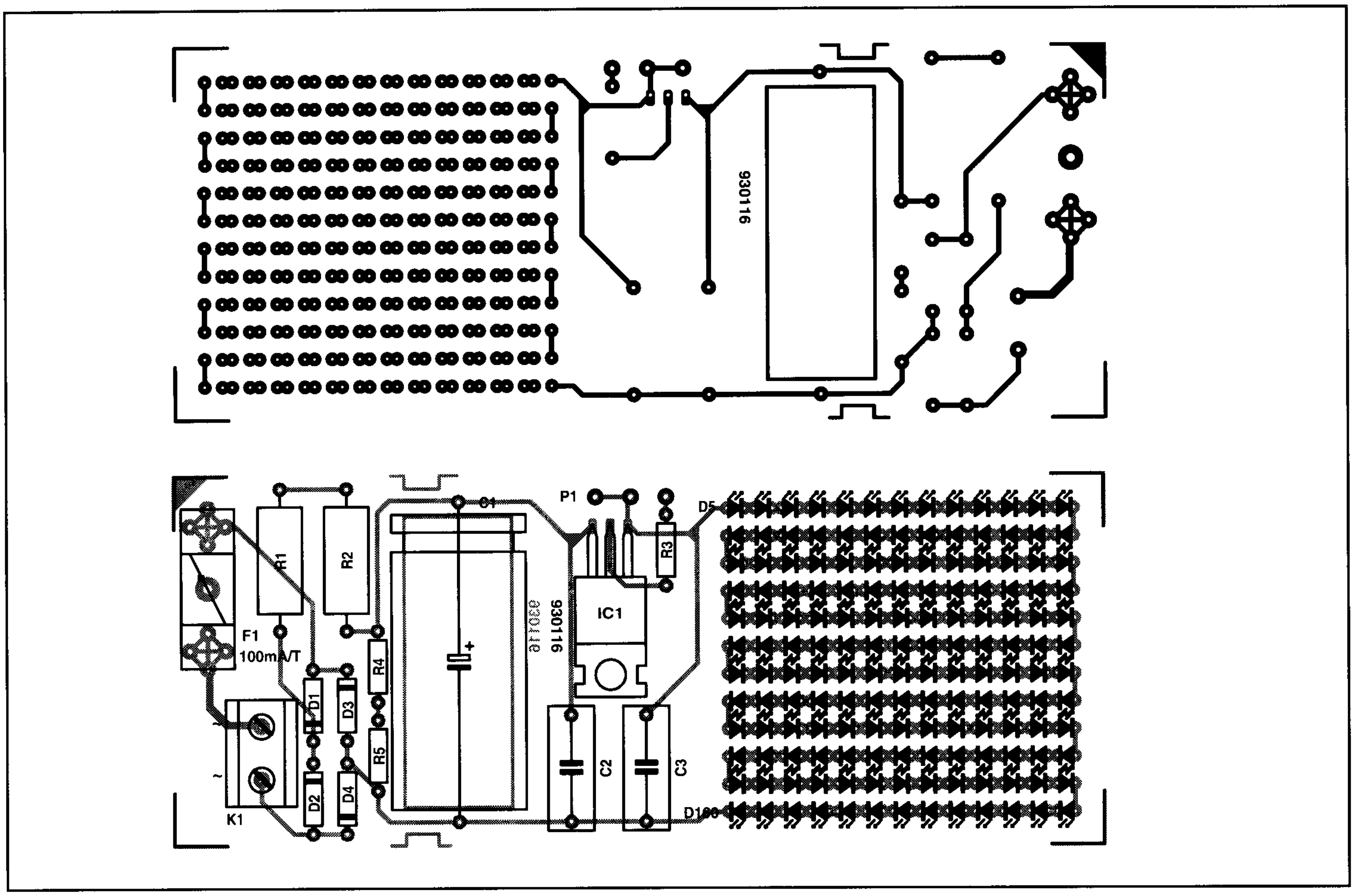


Fig. 3. The size of the PCB matches the inside dimensions of a transparent Type 'Profi' enclosure from Heddic.

COMPONENTS LIST

Resistors:		
2	330Ω 2W	R1;R2
1	39Ω	R3
2	470kΩ	R4;R5
1	100Ω potentiometer w. plastic spindle	P1
Capacitors:		
1	47μF 350V	C1
2	100nF 400V	C2;C3
Semiconductors:		
4	1N4004	D1-D4
156	3mm LED (max. number, see Table 1)	D5-D160
1	TL783C	IC1
Miscellaneous:		
1	2-way PCB terminal block, pitch 7.5mm	K1
1	PCB mount fuseholder w. 100mA slow fuse	F1
1	Enclosure, e.g., Heddic Profi	

Exposure test

Before actually using the LED lamp as a darkroom light, it is necessary to make sure that it does not affect the photographic paper. Before the test, mount the lamp at the desired position in the darkroom. Next, put a piece of photographically sensitive paper where you would normally be working, and then closest to the lamp. A part of the paper is covered, and the other, 'exposed' for two minutes to the light emitted by the LED lamp. Next, the paper is developed in the usual way. If everything is in order no difference may be visible between the exposed and the unexposed part of the paper. If differences are noticed, the intensity of the lamp must be reduced with P1, or different types of yellow LED must be fitted. In both cases, the exposure test must be repeated.

A simpler alternative to the above test is to connect a few LEDs in series with a resistor, power them from a 9-V battery, and suspend them above the photographic paper. After developing the paper you have a clear indication of the LED type that has the smallest effect.

■

LIGHT-EMITTING DIODES (LEDs)

Like the normal diode, the light-emitting diode, or LED, consists of a piece of semiconductor material with an 'n' and a 'p' layer. If a forward current flows through the semiconductor material, the re-combination of electrons in the barrier junction between the 'n' and the 'p' layer gives rise to photon emission; in other words, light is emitted. This form of light emission is called p-n barrier luminescence. The same effect also occurs in normal germanium and silicon diodes. In these semiconductor materials, however, the p-n barrier luminescence efficiency is so small that it can not be put to practical use. The semiconductor material gallium-arsenide (GaAs), however, is far better suited to producing LEDs — a high intensity is achieved at fairly low currents already (a few mA).

LEDs emit virtually monochromatic light, which means that all light energy is contained in a narrow band of the spectrum. A GaAs LED produces light with a wavelength of 868 nm (red light). Similarly, other semiconductor materials are used to generate colours such as green, orange and even blue.

At last, a fully functional upgradeable PCB CAD system to suit any budget. Substantial trade-in discounts are available against other "professional" PCB design packages ...

... call now for details.

BoardCapture

Schematic Capture Design Tool **£395**

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)

- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2

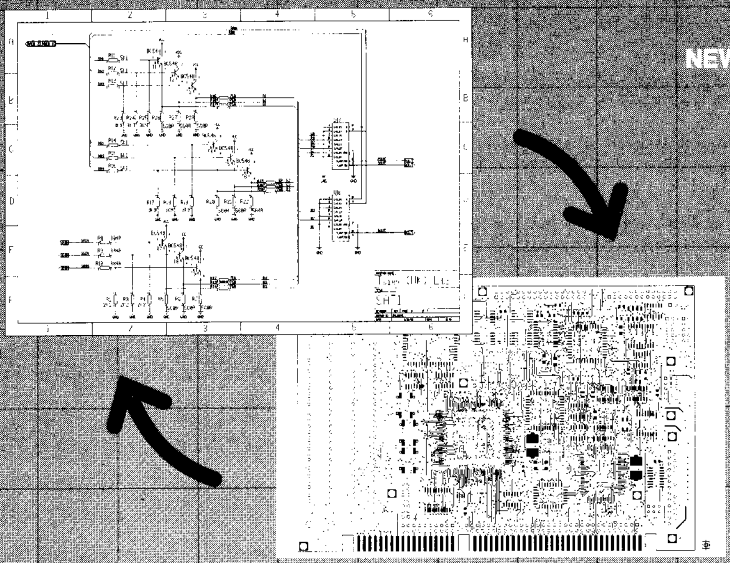
BoardMaker

BoardMaker1 - Entry level **£95**

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level **£295**

- All the features of BoardMaker1 +
- Full netlist support - BoardCapture, OrCad, Schema, Tango, CadStar and others
- Full Design Rule Checking both mechanical and electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator - Database ASCII, BOM
- NEW Thermal power plane support with full DRC



BoardRouter

Gridless re-entrant autorouter **£200**

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

Output drivers - Included as standard

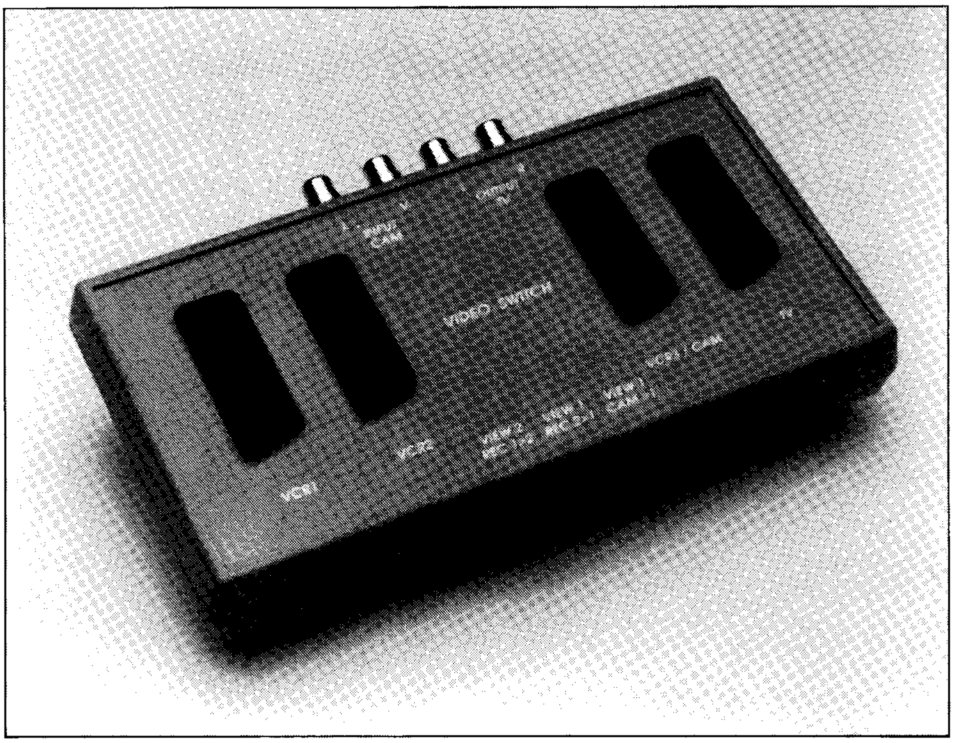
- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill and Annotated drill drawings (BM2)

Call, write or fax for more information
or a full evaluation kit
Tsien (UK) Limited
Aylesby House
Wenny Road, Chatteris
Cambridge
PE16 6UT
Tel (0354) 695959
Fax (0354) 695957

tsien

All trademarks acknowledged

SCART SWITCHING BOX



Now that the camcorder is here to stay as the mobile complement to the trusty video recorder, a problem has come about: selecting between different video signals that can be applied to the SCART input on the TV set. This article describes a simple three-input switching unit for video sources with mono sound. Provision has been made for copying between video recorders connected to the SCART switching box.

Design by L. Pijpers

SOME twenty to thirty years ago, the situation with audio equipment was, in a way, similar to that as it exists for video equipment today. In the old days, one had a radio with one input for a record player ('pickup'). Today's 'video' equivalent would be a TV set and one video recorder. In the course of time, the tape recorder appeared on the scene, and what was once known as a radio set gradually 'fell apart' into a tuner and an amplifier. This gave rise to a number of switching options required to connect the signal sources to the amplifier and/or the available recorders. Although a video installation with a switching layout similar to modern hi-fi sets will not be with us for a few years, it is not unusual for video and TV lovers to have one or two video recorders and a camcorder. Unfortunately, a TV set with two video inputs is not a complete solution, since it does not allow copying between the recorders. The SCART switching box described in this article enables you to enjoy all switching possibilities that you have come to appreciate from your audio equipment, for video!

Block diagram

The SCART selector could not be simpler: switches are used to establish and break connections — see the block diagram in **Fig. 1**. The switches used here are locking buttons which are coupled such that only one switch can be pushed in at a time. The advantage of the switch unit is that it allows you to determine the number of positions of the assembly (1 to 10), while the individual switches are available with 2, 4, 6, 8 and 10 change-over contacts. In this respect, the push-button assembly is much more flexible than the perhaps more usual rotary switch. Moreover, the switch assembly may be mounted directly on to the printed circuit board, which eliminates wire links between the switches and the PCB. On the down side, the push-button assembly is more difficult to fit into a front panel than a rotary switch, which requires only one hole to be drilled.

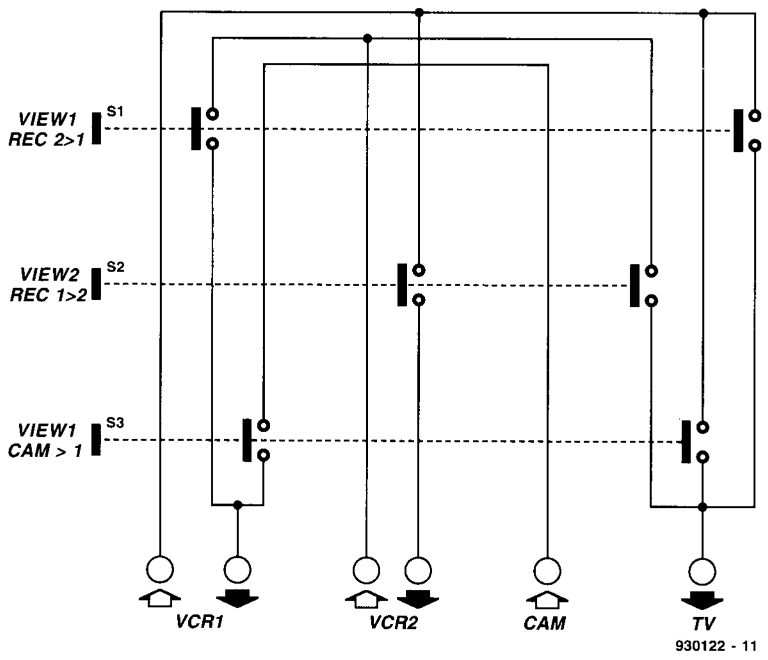


Fig. 1. Block diagram showing how the connections between the equipment are established and broken.

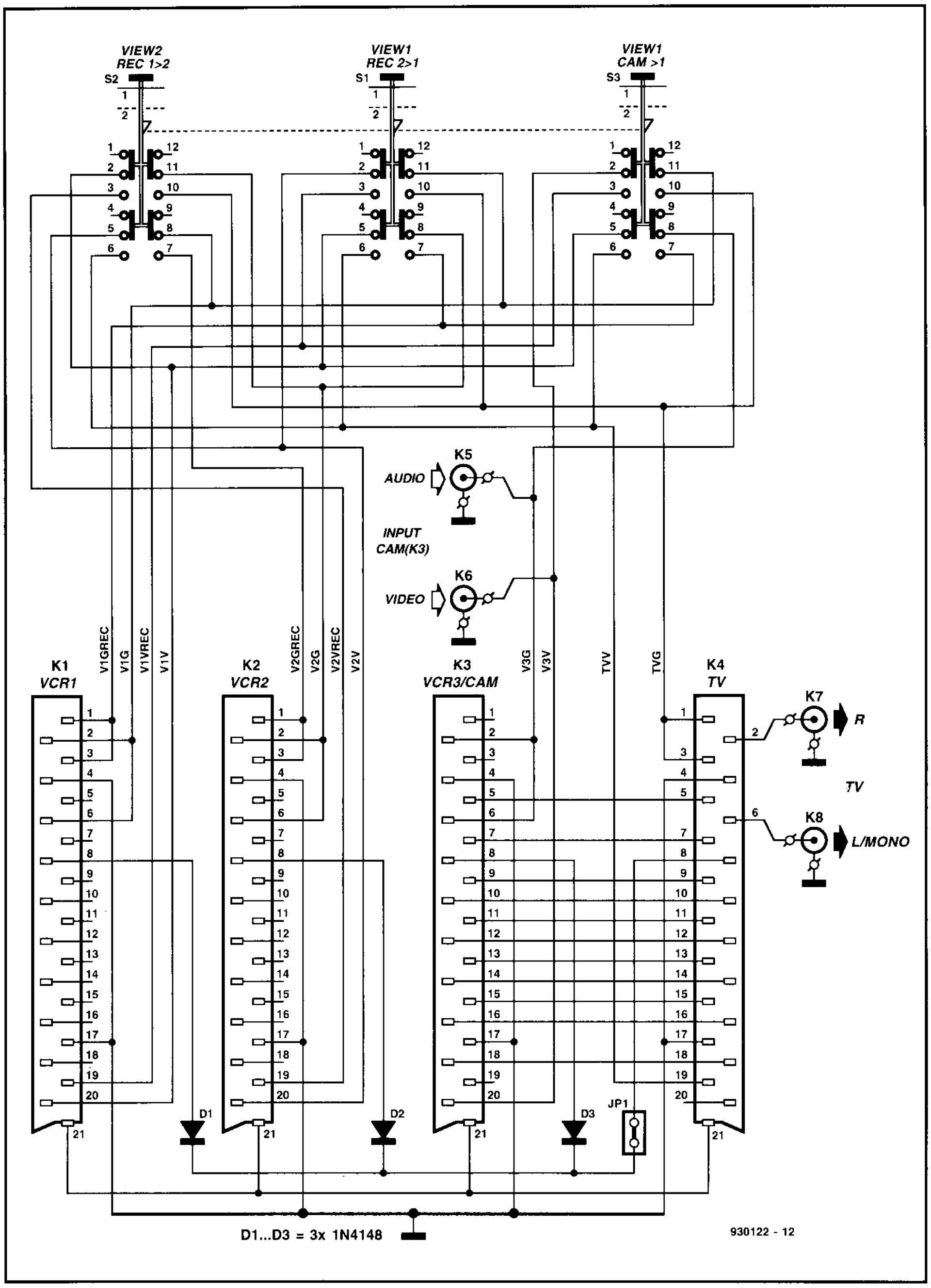
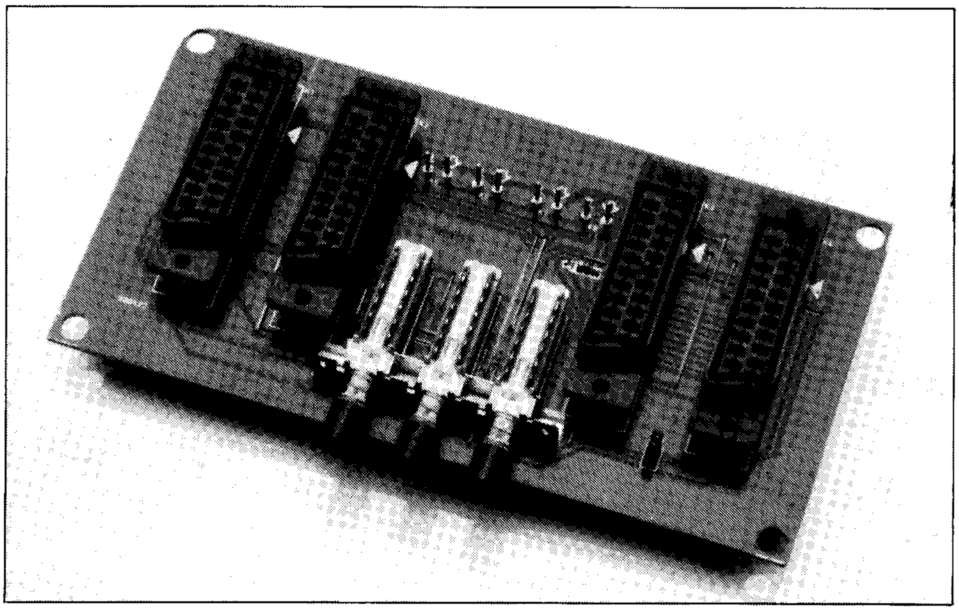


Fig. 2. Circuit diagram of the SCART switching box. The number of components has been kept as small as possible.



The circuit

The circuit diagram of the SCART switching box is shown in **Fig. 2**. To keep the circuit as simple as possible, it was decided not to wire the switching box for S-VHS or Hi8 and stereo sound. This limitation reduces the switching work to one video and one audio signal per connection. Actually, since the audio and video links run side by side, **Fig. 2** is just a double implementation of the block diagram in **Fig. 1**.

To increase the practical possibilities of the SCART switch, the camcorder connection (phono sockets K5 and K6) is connected in parallel to SCART socket K3, to which a third recorder may be linked. Note, however, that this third recorder can be used in 'play' mode only — K3 does not supply a signal that can be used for recording. This makes the K3 socket ideal for connecting a video player.

Most video recorders supply a switching signal which enables a TV or monitor to automatically change to the video signal supplied by the recorder. This switching signal is conveyed via the SCART link between the recorder and the TV. Diodes D1, D2 and D3 form an OR function for the three switching signals, and prevent the recorders from interfering with one another. Remove jumper JP1 if you prefer to switch your TV to 'audio/visual' (AV) manually.

As a finishing touch, the TV sound which arrives on K4 is connected to two phono sockets (since it was extremely simple to realize, this has been done in stereo). In this way, the TV sound is readily connected to the audio rack.

Construction

The layout of the printed circuit board designed for the SCART switching box is given in **Fig. 3**. Construction is simple since the circuit consists mainly of switches and SCART sockets. Start by fitting the wire links, the diodes, the jumper and the terminal pins to which the phono sockets are connected. Next, fit the SCART sockets on to the board. These sockets should be types with **straight** solder pins (angled pin types are more commonly found, but unfortunately can not be used here).

The push-button block has to be assembled before it can be mounted on to the board. Fortunately, assembling the unit is relatively straightforward and almost self-evident from the construction of the individual parts. For the sake of clarity, the assembly is shown in **Fig. 4**. The function of the drivebar spring (part FRV) may not be immediately evident. This tiny but es-

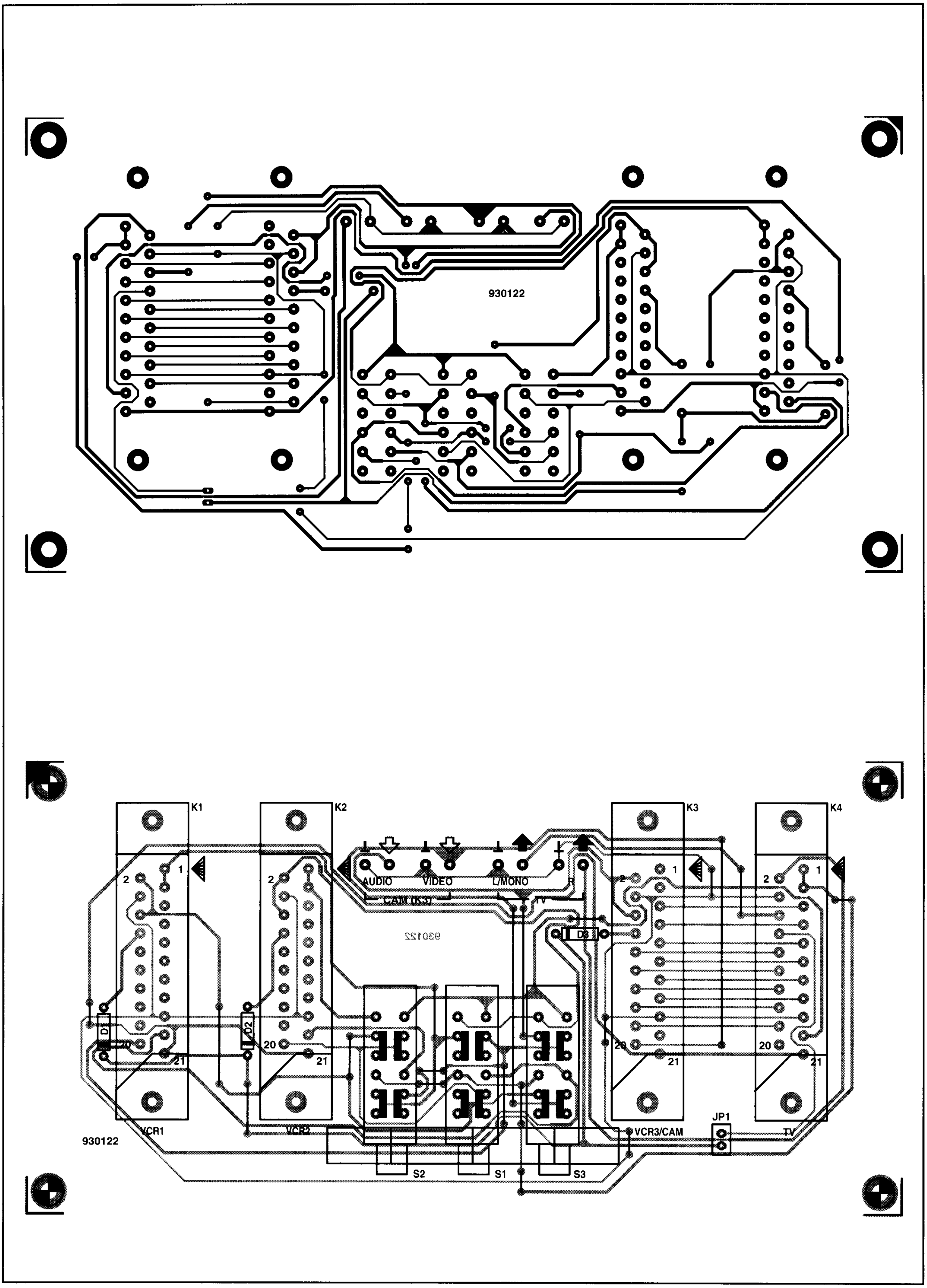


Fig. 3. Printed circuit board for the SCART switch (available ready-made through the Readers Services).

COMPONENTS LIST

Semiconductors:

3	1N4148	D1;D2;D3

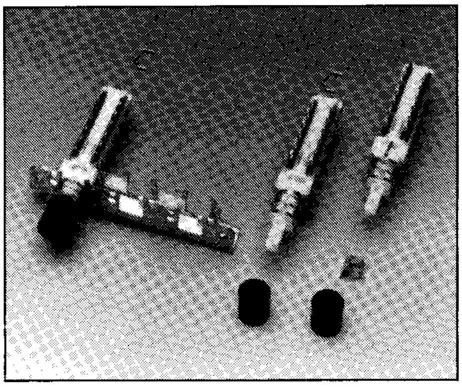
Miscellaneous:

4	PCB mount SCART socket with straight solder pins	K1-K4
4	Panel mount cinch socket	K5-K8
3	Coupled switches Components:	
	3 off 4-way switch F-4U/EE	FS4
	1 off front frame 3F17,5	FF37
	1 off drive bar 3F17,5	FR37
	1 off drive bar spring	FRV
	3 off button 8.8mm dia, black (ITT/Schadow switches [1])	FG0
1	Jumper 0.1 in	JP1
1	Enclosure o.d. 102×191×29mm, e.g. Pactec [2] type HPLkit.	
1	Printed circuit board 930122 (see page 110).	

[1] ITT MultiComponents (0753) 824131.

[2] OK Industries Ltd. (0703) 650055.

sential part serves to secure the drive-bar which locks and unlocks the switches. The spring is fitted on to the right-hand side (viewed from the front side) of one of the switches. As shown in the drawing, the T-shaped part of the spring is pushed into the slot in the corner between the top and the side of the switch. Next, secure the switch just like the other two by bending the protruding cams to the front and to the back. The switch assembly is then ready to be mounted on to the printed circuit board. The push-buttons may be fitted later when the completed PCB has been mounted into an enclosure. The centre-to-centre distance of the three holes that must be drilled for the push-buttons is 17.5 mm. ■



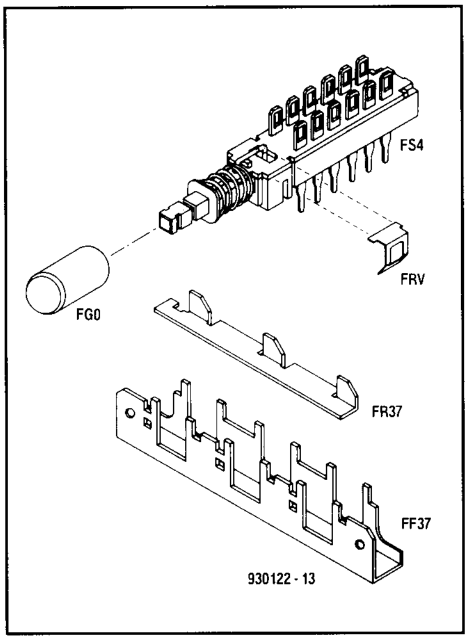


Fig. 4. Illustrating the assembly of switches S1, S2 and S3.

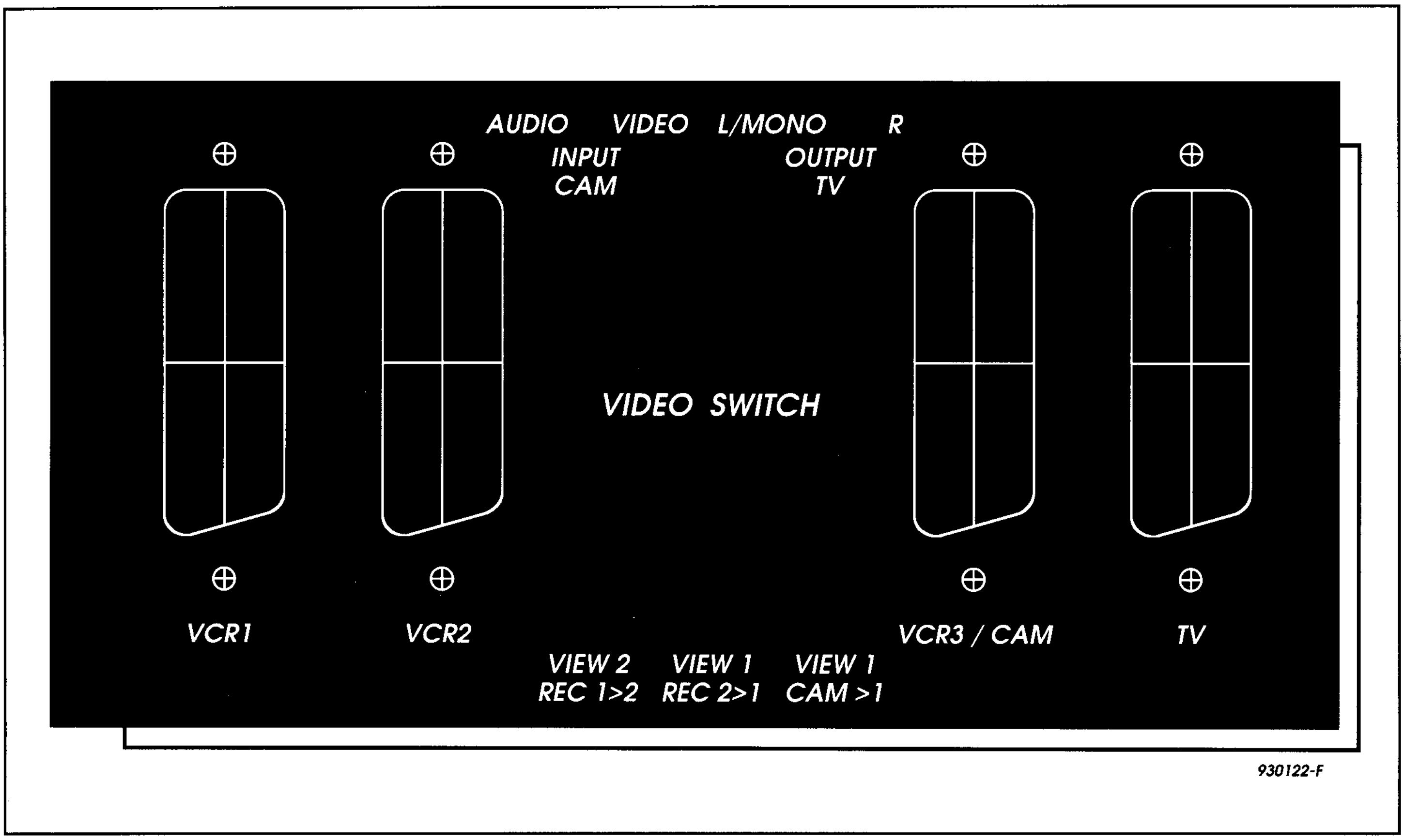


Fig. 5. Suggested front panel layout shown at true size (not available ready-made).

CHOOSING COMPONENT VALUES FOR *L-C* RESONANT TANK CIRCUITS

Resonant 'tank' circuits consist of combinations of inductance (*L*) and capacitance (*C*) elements configured in such a manner that a single frequency — or more correctly a very narrow band of frequencies — is selected, while frequencies removed from the selected frequency are rejected.

By Joseph J. Carr

THE selection of a specific frequency occurs when the inductive reactance ($+X_L$) and capacitive reactance ($-X_C$) have equal magnitude, so therefore cancel each other. **Figure 1** shows two forms of *LC* resonant tank circuit, and a plot of impedance versus frequency. The parallel resonant form is shown in **Fig. 1a**, while the series resonant form is shown in **Fig. 1b**. The following rules apply to these forms (see **Fig. 1c**):

1. a parallel resonant circuit has a maximum impedance at its resonant frequency (F_0); and
2. a series resonant circuit has a minimum impedance at its resonant frequency (F_0).

In some cases, one of these types is clearly preferred over the other, but in other cases either could be used if it is used correctly. For example, in a wave trap — i.e., a circuit that prevents a particular frequency from passing — a **parallel resonant circuit in series with the signal line** will block its resonant frequency while passing all frequencies removed from resonance; a **series resonant circuit shunted across the signal path** will bypass its resonant frequency to common (or 'ground'), while allowing frequencies removed from resonance to pass.

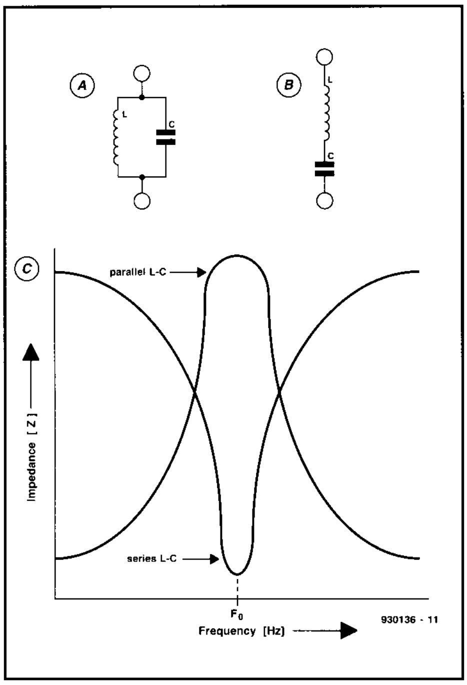


Fig. 1. a) Parallel resonant tank circuit; b) series resonant tank circuit; c) impedance-vs-frequency curves for series and parallel tank circuits.

LC resonant tank circuits are used to tune radio receivers; it is these circuits that select the station to be received, while rejecting others. A superheterodyne radio receiver (the most common type) is shown in simplified form in **Fig. 2**. According to the superhet principle, the radio frequency being received (F_{RF}) is converted to another frequency, called the **intermediate frequency** (F_{IF}), by being mixed with a **local oscillator** signal (F_{LO}) in a non-linear mixer stage. The output of the untamed mixer would be a collection of frequencies defined by:

$$F_{IF} = mF_{RF} \pm nF_{LO} \qquad (1)$$

Where *m* and *n* are either integers or zero. For the simplified case which is the subject of this article, only the first set of products ($m=n=1$) are considered, so the output spectrum will consist of F_{RF}, F_{LO}, $[F_{RF} - F_{LO}]$ (difference frequency), and $[F_{RF} + F_{LO}]$ (sum frequency). In older radios, for practical reasons the difference frequency was selected for F_{IF}; today, either sum or difference frequencies can be selected depending on the design of the radio.

There are several *LC* tank circuits present in this notional superhet radio. The antenna tank circuit (C_1-L_1) is found at the input of the RF amplifier stage, or if no RF amplifier is used it is at the input to the mixer stage. A second tank circuit (L_2-C_2), tuning the same range as L_1-C_1 is found at the output of the RF amplifier, or the input of the mixer. Another *LC* tank circuit (L_3-C_3) is used to tune the local oscillator; it is this tank circuit that sets the frequency that the radio will receive.

Additional tank circuits (only two shown) may be found in the IF amplifier section of the radio. These tank circuits will be fixed tuned to the IF frequency, which in common AM broadcast band (BCB) radio receivers is typically

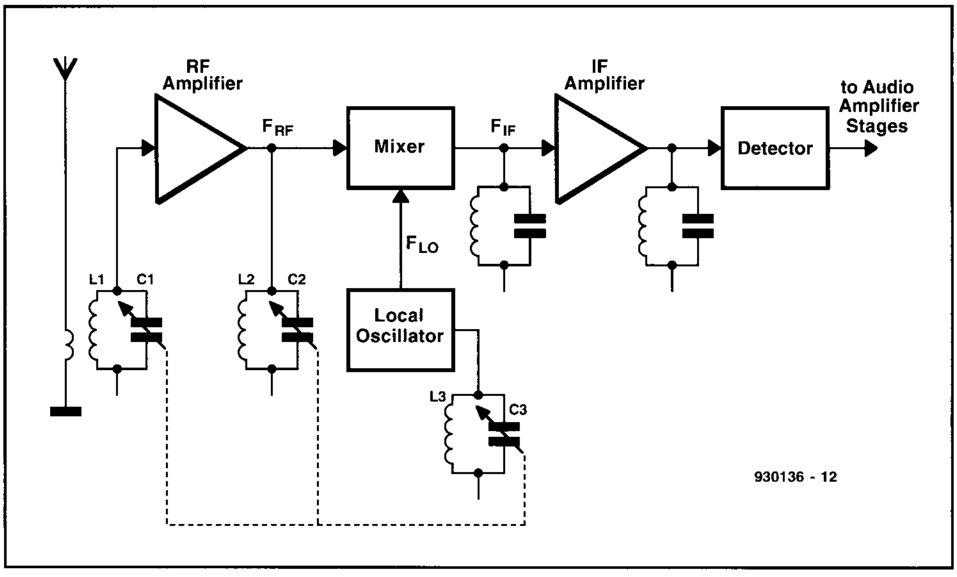


Fig. 2. *LC* tank circuits in a superheterodyne receiver.

450 kHz, 455 kHz, 460 kHz, or 470 kHz depending on the designer's choices (and sometimes country of origin). Other IF frequencies are also seen, but these are most common. FM broadcast receivers typically use a 10.7 MHz IF, while short-wave receivers might use a 1.65 MHz, 8.83 MHz, 9 MHz or an IF frequency above 30 MHz.

The tracking problem

On a radio that tunes the front-end with a single knob, which is almost all receivers today, the three capacitors (*C*1, *C*2 and *C*3 in **Fig. 2**) are typically **ganged**, i.e., mounted on a single rotor shaft. These three tank circuits must **track** each other; i.e., when the RF amplifier is tuned to a certain radio signal frequency, the LO must produce a signal that is different from the RF frequency by the amount of the IF frequency. Perfect tracking is probably impossible, but the fact that your single knob tuned radio works is testimony to the fact that the tracking isn't too terrible.

The issue of tracking *LC* tank circuits for the AM broadcast band (BCB) receiver has not been a major problem for many years: the band limits are fixed over most of the world, and component manufacturers offer standard adjustable inductors and variable capacitors to tune the RF and LO frequencies. Indeed, some even offer three sets of coils: antenna, mixer input/RF amp output and LO. The reason why the antenna and mixer/RF coils are not the same, despite tuning the same frequency range, is that these locations see different distributed or 'stray' capacitances. In the U.S.A., it is standard practice to use a 10 to 365 pF capacitor and a 220 μH inductor for the 540 to 1600 kHz AM BCB. In some other countries, slightly different combinations are sometimes used: 320 pF, 380 pF, 440 pF, 500 pF and others are seen in catalogues (see, for instance, the Maplin Electronics catalogue. Address: P.O. Box 3, Rayleigh, Essex SS6 2BR, England).

Recently, however, two events coincided that caused me to examine the method of selecting capacitance and inductance values. First, I embarked on a design project to produce an AM DXers receiver that had outstanding performance characteristics. Second, the AM broadcast band was recently extended so that the upper limit is now 1700 kHz, rather than 1600 kHz. The new 540 to 1700 kHz band is not accommodated by the now-obsolete 'standard' values of inductance and capacitance. So I calculated new candidate values.

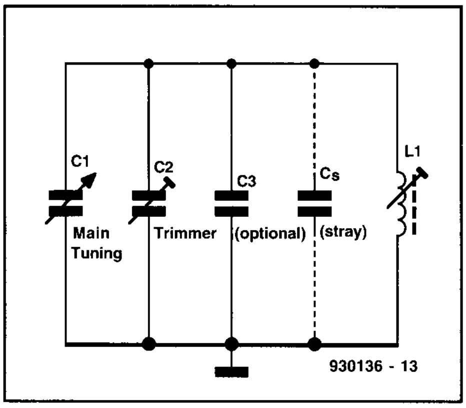


Fig. 3. Parallel resonant tuning circuit.

The RF amplifier/antenna tuner problem

In a typical RF tank circuit, the inductance is kept fixed (except for a small adjustment range that is used for overcoming tolerance deviations) and the capacitance is varied across the range. **Figure 3** shows a typical tank circuit main tuning capacitor (*C*1), trimmer capacitor (*C*2) and a fixed capacitor (*C*3) that is not always needed. The stray capacitance (C_s) includes the interwiring capacitance, the wiring to chassis capacitance, and the amplifier or oscillator device input capacitance. The frequency changes as the square root of the capacitance change. If F_1 is the minimum frequency in the range, and F_2 is the maximum frequency, then the relationship is:

$$\frac{F_2}{F_1}=\sqrt{\frac{C_{\max}}{C_{\min}}} \qquad (2)$$

or, in a rearranged form that some find more congenial:

$$\left(\frac{F_2}{F_1}\right)^2=\frac{C_{\max}}{C_{\min}} \qquad (3)$$

In the case of the new AM receiver, I wanted an overlap of about 15 kHz at the bottom end of the band, and 10 kHz at the upper end, so needed a resonant tank circuit that would tune from 525 kHz to 1710 kHz. In addition, because variable capacitors are widely available in certain values based on the old standards, I wanted to use a 'standard' AM BCB variable capacitor. A 10 to 380 pF unit from a vendor was selected.

The minimum required capacitance, $C_{\min}$, can be calculated from:

$$\left(\frac{F_2}{F_1}\right)^2 C_{\min}=C_{\min}+\Delta C \qquad (4)$$

Where:

F_1 is the minimum frequency tuned;
F_2 is the maximum frequency tuned;
$C_{\min}$ is the minimum required capacitance at F_2;
ΔC is the difference between $C_{\max}$ and $C_{\min}$.

Example

Find the minimum capacitance needed to tune 1710 kHz when a 10 to 380 pF capacitor (ΔC= 380–10 pF = 370 pF) is used, and the minimum frequency is 525 kHz.

Solution:

$$\left(\frac{F_2}{F_1}\right)^2 C_{\min}=C_{\min}+\Delta C$$

$$\left(\frac{1710\,\text{kHz}}{525\,\text{kHz}}\right)^2 C_{\min}=C_{\min}+370\,\text{pF}$$

$$10.609\,C_{\min}=C_{\min}+370\,\text{pF}$$

$$C_{\min}=38.51\,\text{pF}$$

The maximum capacitance must be $C_{\min}$ + ΔC, or 38.51 + 370 pF = 408.51 pF. Because the tuning capacitor (C1 in **Fig. 3**) does not have exactly this range, external capacitors must be used, and because the required value is higher than the normal value additional capacitors are added to the circuit in parallel to *C*1. Indeed, because somewhat unpredictable 'stray' capacitances also exist in the circuit, the tuning capacitor values should be a little smaller than the required values in order to accommodate strays plus tolerances in the actual — versus published — values of the capacitors. In **Fig. 3**, the main tuning capacitor is *C*1 (10 to 380 pF), *C*2 is a small value trimmer capacitor used to compensate for discrepancies, *C*3 is an optional capacitor that may be needed to increase the total capacitance, and C_s is the stray capacitance in the circuit.

The value of the stray capacitance can be quite high, especially if there are other capacitors in the circuit that are not directly used to select the frequency (e.g., in Colpitts and Clapp oscillators the feedback capacitors affect the *LC* tank circuit). In the circuit that I was using, however, the *LC* tank circuit is not affected by other capacitors. Only the wiring strays and the input capacitance of the RF amplifier or mixer stage need be accounted. From experience I apportioned 7 pF to C_s as a **trial** value.

The minimum capacitance calculated above was 38.51, there is a nominal 7 pF of stray capacitance, and the minimum available capacitance from *C*1 is 10 pF. Therefore, the combined values of *C*2 and *C*3 must be (38.51–10–7 pF), or 21.5 pF. Because there is considerable reasonable doubt about the actual value of C_s, and because of tolerances in the manufacture of the main tuning variable capacitor (*C*1), a wide range of capacitance for *C*2+*C*3 is preferred. It is noted from several catalogues that 21.5 pF is near the centre of the range of 45 pF and 50 pF trimmer capacitors. For example, one model lists its range as 6.8 pF to 50 pF, its centre point is only slightly removed from the actual desired capacitance. Thus, a 6.8 to 50 pF trimmer was selected, and *C*3 is not used.

Selecting the inductance value for *L*1 (**Fig. 3**) is a matter of picking the frequency and associated required capacitance at one end of the range, and calculating from the standard resonance equation solved for *L*:

$$L = \frac{10^6}{4\pi^2 F^2_{\text{low}} C_{\text{max}}} \ \mu\text{H} \qquad (5)$$

$$L = \frac{10^6}{4\pi^2 (525{,}000)^2 (4.085\times 10^{-10})}$$

$$L = 224.97 = 225\,\mu\text{H}$$

The RF amplifier input *LC* tank circuit and the RF amplifier output *LC* tank circuit are slightly different cases because the stray capacitances are somewhat different. In the example, I am assuming a JFET transistor RF amplifier, and it has an input capacitance of only a few picofarads. The output capacitance is not a critical issue in this specific case because I intend to use a 1 mH RF choke in order to prevent JFET oscillation. In the final receiver, the RF amplifier may be deleted altogether, and the *LC* tank circuit described above will drive a mixer input through a link coupling circuit.

The local oscillator (LO) problem

The local oscillator circuit must track the RF amplifier, and must also tune a frequency range that is different from the RF range by the amount of the IF frequency (455 kHz). In keeping with common practice I selected to place the LO frequency 455 kHz **above** the RF frequency. Thus, the LO must tune the range 980 kHz to 2,165 kHz.

There are three methods for making the local oscillator track with the RF amplifier frequency when single shaft tuning is desired: the **trimmer capacitor** method, the **padder capacitor** method, and the **different-value cut-plate capacitor** method.

The trimmer capacitor method was shown in **Fig. 3**, and is the same as the RF *LC* tank circuit. Using exactly the same method as before, but with a frequency ratio of (2165/980) to yield a capacitance ratio of $(2165/980)^2$ = 4.88:1, solves this problem. The results were a minimum capacitance of 95.36 pF, and a maximum capacitance of 465.36 pF. An inductance of 56.7 µH is needed to resonate these capacitances to the LO range.

There is always a problem associated with using the same identical capacitor for both RF and LO. It seems that there is just enough difference that tracking between them is always a bit off. **Figure 6** shows the ideal LO frequency and the calculated LO frequency. The difference between these two curves is the degree of non-tracking. The curves

```
100 'PROGRAM TO CALCULATE L-C TANK CIRCUIT VALUES
110 'A color monitor is needed for this program. If no color monitor is
120 'is used, then delete Line Nos. 140 and 150.
130   CLS:KEY OFF
140   SCREEN 9
150   GOSUB 1030:'Get graphic of circuit diagram
160 'Start of program
170     CLS:KEY OFF:SCREEN SCR:PI = 22/7
180 IF SCR > 0 THEN COLOR 1,7
190  LOCATE 6,15:PRINT "Calculate L-C tank circuit values from knowledge"
200  LOCATE  7,15:PRINT "of desired frequency range and variable capacitor"
210  LOCATE  8,15:PRINT "values (in picofards)."
220  LOCATE 10,15:PRINT "Enter MINIMUM frequency (F1)in kilohertz (KHz):";
230      INPUT F1$:' Obtain value of lowest frequency
240        F1 = VAL(F1$):' Test input of F1 to see if zero
250          IF F1 = 0 THEN BEEP
260          IF F1 = 0 THEN 220 ELSE 270
270  LOCATE 12,15:PRINT "Enter MAXIMUM frequency (F2) in kilohertz (KHz):";
280      INPUT F2$:' Obtain value of highest frequency
290        F2 = VAL(F2$):' Test input of F2 to see if zero
300          IF F2 = 0 THEN BEEP
310          IF F2 = 0 THEN 270
320            IF F2 = F1 THEN GOSUB 1440:'Test for incorrect freq. input
330            IF F1 > F2 THEN GOSUB 1440
340            IF F2 = F1 THEN 160 ELSE 350
350            IF F1 > F2 THEN 160 ELSE 360
360  LOCATE 14,15:PRINT "Select Capacitor Values..."
370  LOCATE 16,15:PRINT "Enter MINIMUM value of capacitor in picofarads (pF):";
380      INPUT CMIN$
390        CMIN = VAL(CMIN$)
400          IF CMIN = 0 THEN BEEP
410          IF CMIN = 0 THEN 360 ELSE 420
420  LOCATE 18,15:PRINT "Enter MAXIMUM value of capacitor in picofarads (pF):";
430      INPUT CMAX$
440        CMAX = VAL(CMAX$)
450          IF CMAX = 0 THEN BEEP
460          IF CMAX = 0 THEN 420 ELSE 470
470            IF CMIN = CMAX THEN GOSUB 1480:'Test for incorrect cap. input
480            IF CMIN > CMAX THEN GOSUB 1480:'and display error message
490            IF CMIN = CMAX THEN 360 ELSE 500
500            IF CMIN > CMAX THEN 360 ELSE 510
510  CLS:'Clear screen and print all entered values
520  LOCATE 6,15:PRINT "Minimum frequency (F1):";F1;" KHz"
530  LOCATE 7,15:PRINT "Maximum frequency (F2):";F2;" KHz"
540   LOCATE 9,15:PRINT "Minimum capacitance in C1: ";CMIN;" pF"
550   LOCATE 10,15:PRINT "Maximum capacitance in C1: ";CMAX;" pF"
560      FRATIO = F2/F1:'Calculate frequency ratio
570      CRATIO = FRATIO^2:'Calculate capacitance ratio
580      CDELTA = CMAX-CMIN
590   LOCATE 11,15:PRINT "Frequency ratio: ";
600     PRINT USING "##.###";FRATIO;:PRINT ":1"
610   LOCATE 12,15:PRINT "Required capacitance ratio: ";
620     PRINT USING "##.###";CRATIO;:PRINT ":1"
630   LOCATE 13,15:PRINT "Capacitance differential: ";
640     PRINT USING "####.##";CDELTA;:PRINT " pF"
650   XMIN = CDELTA/(CRATIO - 1):'Calculate min. total cap. needed
660   XMAX = CDELTA + XMIN:' Calculate max. total cap. needed
670   TRIMCAP = XMIN - CMIN
680     IF TRIMCAP < 0 THEN GOSUB 1580 ELSE 690
690     IF TRIMCAP < 0 THEN 160 ELSE 700
700   LOCATE 15,15:PRINT "Trimmer capacitance needed: ";
710   PRINT USING "####.##";TRIMCAP;:PRINT " pF"
720     LUH = 1/(4*PI^2*F1^2*XMAX*10^-12)
730   LOCATE 16,15:PRINT "Inductance needed: ";
740   PRINT USING "####.##";LUH;:PRINT " uH"
750   LOCATE 18,15:PRINT "Allocate a few pF for strays and then make up"
760   LOCATE 19,15:PRINT "remaining capacitance with either fixed or variable"
770   LOCATE 20,15:PRINT "trimmer capacitors."
780   LOCATE 22,15:GOSUB 1630:'Get press any key subroutine
790   CLS:'Clear screen for new message
800   LOCATE 10,15:PRINT "The trimmer capacitance will include all capacitances"
810   LOCATE 11,15:PRINT "seen by the inductor, and that could include a large"
820   LOCATE 12,15:PRINT "capacitance in other parts of the circuit. In certain"
830   LOCATE 13,15:PRINT "oscillator circuits, especially Colpitts and Clapp"
840   LOCATE 14,15:PRINT "oscillators, the other capacitances are large."
850   LOCATE 15,15:PRINT "Check a good oscillator design handbook for further"
860   LOCATE 16,15:PRINT "information."
870   LOCATE 18,15:GOSUB 1630
880   CLS:LOCATE 12,15:PRINT "(D)o Another Problem?"
890   LOCATE 13,15:PRINT "(E)nd Program?"
900   CHOICE$ = INPUT$(1)
910   IF CHOICE$ = "D" THEN CHOICE = 1
920   IF CHOICE$ = "d" THEN CHOICE = 1
930   IF CHOICE$ = "E" THEN CHOICE = 2
940   IF CHOICE$ = "e" THEN CHOICE = 2
950      IF CHOICE < 1 THEN 880 ELSE 960
960      IF CHOICE > 2 THEN 880 ELSE 970
970      IF INT(CHOICE) = CHOICE THEN 980 ELSE 880
980   ON CHOICE GOTO 160,990
990 CLS:LOCATE 12,20:PRINT "Program Ended...Goodbye"
1000  TIMELOOP=TIMER:WHILE TIMER < TIMELOOP + 2:WEND
1010 CLS
1020 END
1030 'Subroutine to draw circuit picture on screen
1040 CLS:LINE (450,100)-(100,100):'Draw connecting rails
1050 LINE (450,200)-(100,200)
1060 LINE (175,180)-(165,120),,B:'Draw inductor L1
1070 LINE (170,200)-(170,180)
1080 LINE (170,120)-(170,100)
1090 LINE (175,180-ZZ)-(165,180-ZZ)
1100 ZZ = ZZ + 5
1110 IF ZZ =  60 GOTO 1130
1120 GOTO 1090
1130 LINE (250,200)-(250,153):'Draw C1 (main tuning capacitor)
1140 LINE (250,147)-(250,100)
1150 LINE (265,153)-(235,153)
1160 LINE (265,147)-(235,147)
1170 LINE (265,165)-(235,135)
1180 LINE (350,200)-(350,153):'Draw C2 (trimmer capacitor)
1190 LINE (350,147)-(350,100)
1200 LINE (365,153)-(335,153)
1210 LINE (365,147)-(335,147)
1220 LINE (365,165)-(335,135)
1230 LINE (450,200)-(450,153):'Draw stray capacitances
1240 LINE (450,147)-(450,100)
1250 LINE (465,153)-(435,153)
1260 LINE (465,147)-(435,147)
1270 LINE (102,102)-(98,98),1,B
1280 LINE (102,202)-(98,198),1,B
1290 LINE (252,202)-(248,198),1,BF
1300 LINE (252,102)-(248,98),1,BF
1310 LINE (352,202)-(348,198),1,BF
1320 LINE (352,102)-(348,98),1,BF
1330 LINE (172,202)-(168,198),1,BF
1340 LINE (172,102)-(168,98),1,BF
1350 LOCATE 11,19:PRINT "L1":'Add alphabetic labels
1360 LOCATE 11,27:PRINT "C1"
1370 LOCATE 11,40:PRINT "C2"
1380 LOCATE 11,49:PRINT "Stray"
1390 LOCATE 16,15:PRINT "C1 is main tuning capacitor"
1400 LOCATE 17,15:PRINT "C2 is trimmer + fixed capacitors"
1410 LOCATE 18,15:PRINT "Stray is wiring capacitance plus other"
1420 LOCATE 19,15:PRINT "capacitors in the circuit."
1430 LOCATE 21,15:GOSUB 1630:CLS:RETURN:'End of Subroutine
1440 ' Error Message Subroutine (Incorrect Frequency Input)
1450   BEEP:LOCATE 17,15:PRINT "ERROR!  F2 must be greater than F1"
1460   LOCATE 19,15:GOSUB 1630:' Go get press any key subroutine
1470 RETURN:'End of Subroutine
1480 'Error Message Subroutine (Incorrect Capacitance Input)
1490  BEEP:LOCATE 20,15:PRINT "ERROR! Cmax must be greater than Cmin"
1500   LOCATE 22,15:GOSUB 1630:' Go get press any key subroutine
1510   GOSUB 1530:'Clear screen and reprint F1 and F2
1520  RETURN:' End of Subroutine
1530 ' Subroutine to clear screen and reprint values of F1 and F2
1540  CLS
1550  LOCATE 6,15:PRINT "Minimum frequency (F1):";F1;" KHz";
1560  LOCATE 7,15:PRINT "Maximum frequency (F2):";F2;" KHz"
1570 RETURN:'End of Subroutine
1580 'Subroutine for Too Small Trimmer Capacitance
1590  CLS
1600  LOCATE 12,15:PRINT "ERROR!!! Not a viable combination...try again"
1610  LOCATE 14,15:GOSUB 1630:'Go get press any key subroutine
1620  RETURN
1630 ' Press Any Key... Subroutine
1640 PRINT "Press Any Key To Continue..."
1650 A$ = INKEY$:IF A$ = "" THEN 1650 ELSE 1660
1660 RETURN:'End of Subroutine
```

930136-16

Fig. 4. BASIC program to calculate RF tank circuit component values.

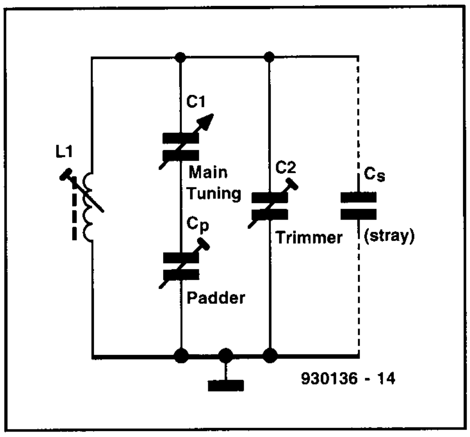


Fig. 5. Parallel resonant tank circuit using the padder capacitor method.

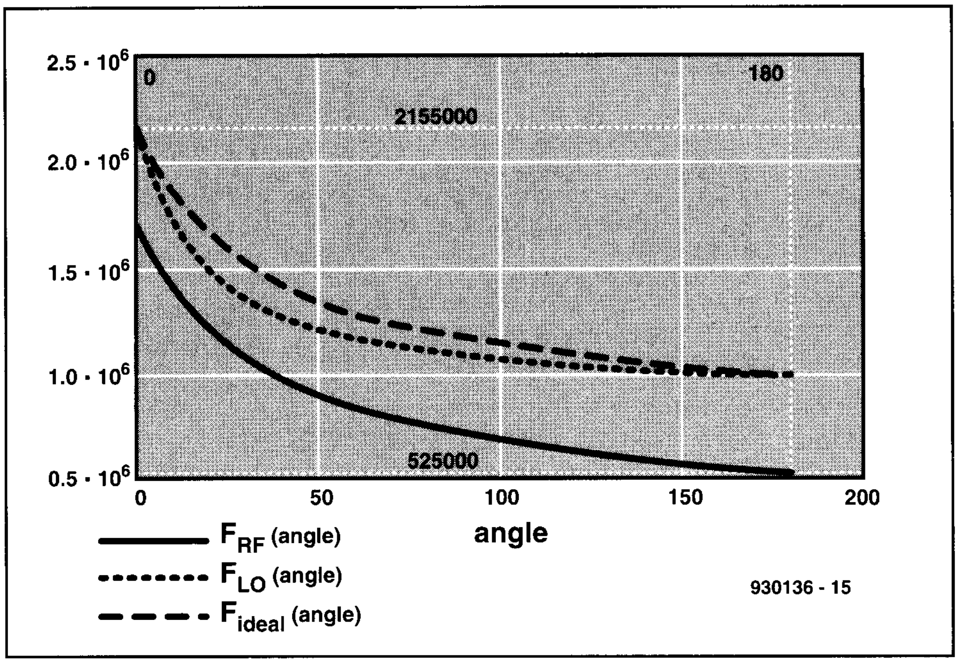


Fig. 6. MathCAD 3.1 plot of RF, LO (ideal) and LO (actual) tuning as a function of capacitor shaft angle.

overlap at the ends, but are awful in the middle. There are two cures for this problem. First, use a **padder capacitor** in series with the main tuning capacitor (**Fig. 5**). Second, use a **different-value cut-plate capacitor**.

Figure 5 shows the use of a padder capacitor (C_p) to change the range of the LO section of the variable capacitor. This method is used when both sections of the variable capacitor are identical. Once the reduced capacitance values of the $C1/C_p$ combination are determined the procedure is identical to above. But first, we have to calculate the value of the padder capacitor and the resultant range of the $C1/C_p$ combination. The padder value is found from:

$$\frac{C1_{max}\,C_p}{C1_{max}+C_p}=\left(\frac{F2}{F1}\right)^2\left(\frac{C1_{min}\,C_p}{C1_{min}+C_p}\right) \qquad (6)$$

...and solving for C_p. For the values of the selected main tuning capacitor and LO:

$$\frac{(380\,\text{pF})C_p}{(380+C_p)\,\text{pF}}=(4.88)\left(\frac{(10\,\text{pF})C_p}{(10+C_p\,\text{pF})}\right)$$

Solving for C_p by the least common denominator method (crude, but it works) yields a padder capacitance of 44.52 pF. The series combination of 44.52 pF and a 10 to 380 pF variable yields a range of 8.2 pF to 39.85 pF. An inductance of 661.85 µH is needed for this capacitance to resonate over 980 kHz to 2,165 kHz.

A practical solution to the tracking problem that comes close to the ideal is to use a **cut-plate** capacitor. These variable capacitors have at least two sections, one each for RF and LO tuning. The shape of the capacitor plates are especially cut to a shape that permits a constant change of **frequency** for every degree of shaft rotation. With these capacitors, when well done, it is possible to produce three-point tracking, or better.■

Books from Elektor Electronics (Publishing)

The following books are currently available:

301 Circuits	£9·95	$14.50
302 Circuits	£9·95	$14.50
303 Circuits	£10·95	$17.90
304 Circuits	£12·95	$23.95
305 Circuits†	£14·95	$27.70
SMT Projects	£ 9·95	$14.50
Microprocessor Data Book	£10·95	$19.90
Data Sheet Book 2	£9·95	$18.50
Data Book 3: Peripheral Chips	£10·95	$19.95
Data Book 4: Peripheral Chips	£10·95	$19.95
Data Book 5: Application Notes	£10·95	$19.95

The books may be obtained from bookshops*, Old Colony Sound Lab (USA and Canadian readers only—for address, see order form on p. 79) or direct from our Dorchester office (private customers only*) on the order form on page 79.

* Orders other than from private customers, for instance, bookshops, schools, colleges, should be sent to

Gazelle Book Services Ltd
Falcon House
Queen Square
Lancaster LA1 1RN
England
Telephone (0524) 68765; Fax (0524) 63232

† Not available until late December/early January

AMAZING PC BASE SALE

WE HAVE ACQUIRED A SELECTION OF **HIGH QUALITY** AMSTRAD PC BASE UNITS AT **MEGA DISCOUNT** PRICES. LOOK WHAT YOU CAN BUY FROM ONLY £19.00!

UNTESTED AMSTRAD PC BASE UNITS COMPLETE WITH MOTHER -BOARD, VIDEO CONTROLLER, DISK CNTRLR, & 5.25" DRIVE(S). (Keyboard, Mouse, PSU & DOS not supplied)

AMSTRAD 1512SD	£19.00	REF: EL/AM19P1
AMSTRAD 1512DD	£25.00	REF: EL/AM25P1
AMSTRAD 1640SD	£25.00	REF: EL/AM25P2
AMSTRAD 1640DD	£30.00	REF: EL/AM30P1

NEW or REFURBISHED PC BASES COMPLETE WITH KEYBOARD, MOUSE, and 5.25" DRIVE. RUNS UNDER MS-DOS VER 3 (DOS not supplied)

All sold guaranteed as new. All you need is a power supply unit & monitor.

AMSTRAD 1512SD	£49.00	REF: EL/AM49P1
AMSTRAD 1512DD	£59.00	REF: EL/AM59P1
AMSTRAD 1640SD	£69.00	REF: EL/AM69P1
AMSTRAD 1640DD	£79.00	REF: EL/AM79P1

LIMITED OFFER

IBM COMPATIBLE LAPTOP COMPUTERS

FROM ONLY £99.00 (plus vat)

AGAIN IN STOCK AT A SUPERB DISCOUNT PRICE!
FULLY **IBM COMPATIBLE LAPTOP** COMPUTERS
OFFERING EITHER **512K** OR **640K** MEMORY.
FLIP UP GREEN SUPERTWIST **LCD SCREEN.**
FULL 'QWERTY' KEYBOARD,
RS232 PRINTER PORT
VIDEO OUT.
RUNS ON **BATTERIES/**
DC SUPPLY/MAINS ADAPTER.
MS-DOS 3.1 RUNS THESE UNITS

AMSTRAD LAPTOP OPTIONS

AMSTRAD PPC 1512 SD (512k memory Single 3.5" disc drive)	£99.00	EL/AM99P1
AMSTRAD PPC 1512 DD (512k memory Two 3.5" disc drive)	£109.00	EL/AM109P1
AMSTRAD PPC 1640 SD (640k memory one 3.5" drive modem)	£129.00	EL/AM129P1
AMSTRAD PPC 1640 DD (640k memory two 3.5" drive modem)	£139.00	EL/AM139P1

MAINS POWER SUPPLY FOR ALL ABOVE LAPTOP UNITS ONLY £10.00

AMAZING COMPUTER BARGAINS

IBM COMPATIBLE LAPTOPS FROM ONLY **£99.00** (PLUS VAT)

COMPUTER BASE UNITS FROM ONLY **£19.00** (PLUS VAT)

LIMITED OFFER - ***HURRY WHILE STOCKS LAST***

AMAZING SALE OF BT ANSWERPHONES

As NEW, fully guaranteed BT Product as LESS than Half the original retail price!!!

RESPONSE 200 AND 400 MODELS

Each Response Unit is supplied with a Micro cassette, PSU and User Details. The following features are found on the 400 Model and the 200 has almost as many features.:-

Micro Cassette
Call Screening
Call Count
Answer only
Last No redial
On hook dialling
BT Network Services
Mute Facility
Ren 1.0.
Memo Facility
Remote Facility
20 Memories
Variable volume
Hands free speach
PABX Compatible
LCD Display

RESPONSE 200 **£35.99** Ref:EL36P1
RESPONSE 400 **£49.99** Ref:EL49P1
(plus vat)

10 WATT SOLAR CELL

(3" x 1") 14.5v/700mA

Now available by mail order

Coated with exceptionally efficient amorphous silicon these glass solar cells have an almost timeless lifespan and will not suffer with discolouration. There are possibly hundreds of uses for these cells, a few of which could be: for **Car Battery Charging**, for useon **Boats** or on **Caravans**, in fact anywhere a portable **12V** supply is required. Several of our overseas Mediterranean customers with homes in remote hilly sites, use these solar cells as a daytime power source to backup generators. The solar cells can be connected in series or parallel to give higher voltages or larger current capacity. **REF: EL34P2**

PRICED at only

£33.95 (plusVAT)

PLUS an additional £2.00 special packaging charge

PORTABLE RADIATION DETECTOR

SPECIAL OFFER
£49.99 (plus vat)

NEVER OFFERED BEFORE............... We can now supply a unique handheld personal portable **Gamma and X-Ray detector.** This **Radiation detector** contains **two Geiger Tubes** has a 4 digit LCD display with a piezo speaker, giving an audio visual indication. The radiation detectors detect high energy electromagnetic quanta with an energy from30KeVtoover1.2MeVandameasuring rate 5-9999 UR/h (sampling rate 2555) or 10-99990 NR/h (sampling rate 2.55) Sources of radiation could be Granite Kerbstones old Luminous Watch dials or even a Jewellery shop where mineral ore is sold to rock collectors. A piece of uranium Ore would be ideal.................................

Only £49.99 Each Ref: EL50P1

MINIMUM GOODS ORDER £5.00 TRADE ORDERS FROM GOVERNMENT, SCHOOLS, UNIVERSITIES & LOCAL AUTHORITIES WELCOME. ALL GOODS SUPPLIED SUBJECT TO OUR CONDITIONS OF SALE AND UNLESS OTHERWISE STATED GUARANTEED FOR 30 DAYS. RIGHTS RESERVED TO CHANGE PRICES & SPECIFICATIONS WITHOUT PRIOR NOTICE. ORDERS SUBJECT TO STOCK. QUOTATIONS WILLINGLY GIVEN FOR QUANTITIES THAN THOSE STATED.

BULL ELECTRICAL

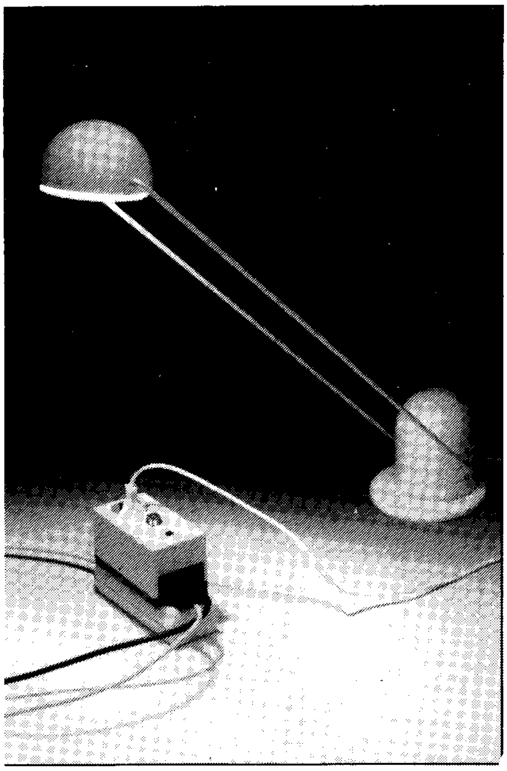
250 PORTLAND ROAD HOVE SUSSEX
BN3 5QT
MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.
PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY
TELEPHONE ORDERS WELCOME
TEL: 0273 203500
FAX: 0273 323077

TURN YOUR SURPLUS STOCK INTO **CASH**. IMMEDIATE SETTLEMENT. WE WILL ALSO QUOTE FOR COMPLETE FACTORY CLEARANCE. MUCH MUCH MORE IN OUR 1993 **CATALOGUE**. PLEASE SEND 41P, A4 SIZED SAE FOR YOUR FREE COPY. ALL OUR PRICES ARE NET OF V.A.T.

I²C POWER SWITCH

A module is described that enables a mains powered device of up to 275 VA to be controlled by a PC via the I²C bus. Since a direct connection to the mains voltage exists in the circuit, great attention has been given in the design to your electrical safety, as well as to protection of the expensive PC.

Design by K. Walraven



WHEREVER a PC is used to switch mains powered apparatus on and off, great care must be exercised with regard to safety, since even a small error can have disastrous consequences. And yet, being able to switch lamps and other (small) nonreactive devices powered from the mains appeals to many PC users. The power switch described in this article enables mains powered, nonreactive, devices of up to 275 VA to be controlled in a safe manner. Provided the user keeps to the construction notes, the electrical insulation provided by the circuit should afford the PC and its user adequate protection against dangerous voltage levels.

The electronics

The small circuit shown in **Fig. 1** is designed to minimize the risk of connecting a PC to devices which are powered from the mains. Safety is achieved essentially with the aid of a solid state relay (SSR) which contains an optoisolator. The heart of the circuit is an 8-bit quasi bidirectional I/O port Type PCF8574 from Philips Semiconductors. This IC is driven via the I²C bus (the associated PC interface card is described in Ref. 1). The PCF8574 comes in two versions: the 'plain' PCF8574 with base address 40H, and the PCF8574A with base address 70H. Since each IC can be located at eight different addresses with the aid of three jumpers (JP1, JP2 and JP3), up to 16 of these circuits can be connected simultaneously to a single I²C bus.

For the sake of safety, the module is fitted into a compact mains adaptor case with a moulded mains plug and socket. This is also the reason for having only one relay per module. The PC and the module communicate via a short length of 5-way cable. The two mini-DIN sockets on the module are typical of all I²C circuits published so far in this magazine (see the 'catch the I²C bus' inset), and allow modules to be 'chained'. The 5-way cable carries the two digital signals SDA and SCL as well as the supply voltage.

Only one of the eight digital I/O ports contained in the PCF8574 is used in every module. Here, output P0 is used to drive the LED in the solid-state relay, ISO1. After an automatic power-on reset, all I/O lines of the PCF8574 are logic high, which means that they function as inputs. Consequently, the power on/off LED and the LED in ISO1 are off after a reset. The triac contained in the electronic relay does not start to conduct until output P0 of IC1 is made logic low. LED D1 then also lights to indicate that the mains load is switched on. The triac in the SSR is shunted by a so-called snubber network. This con-

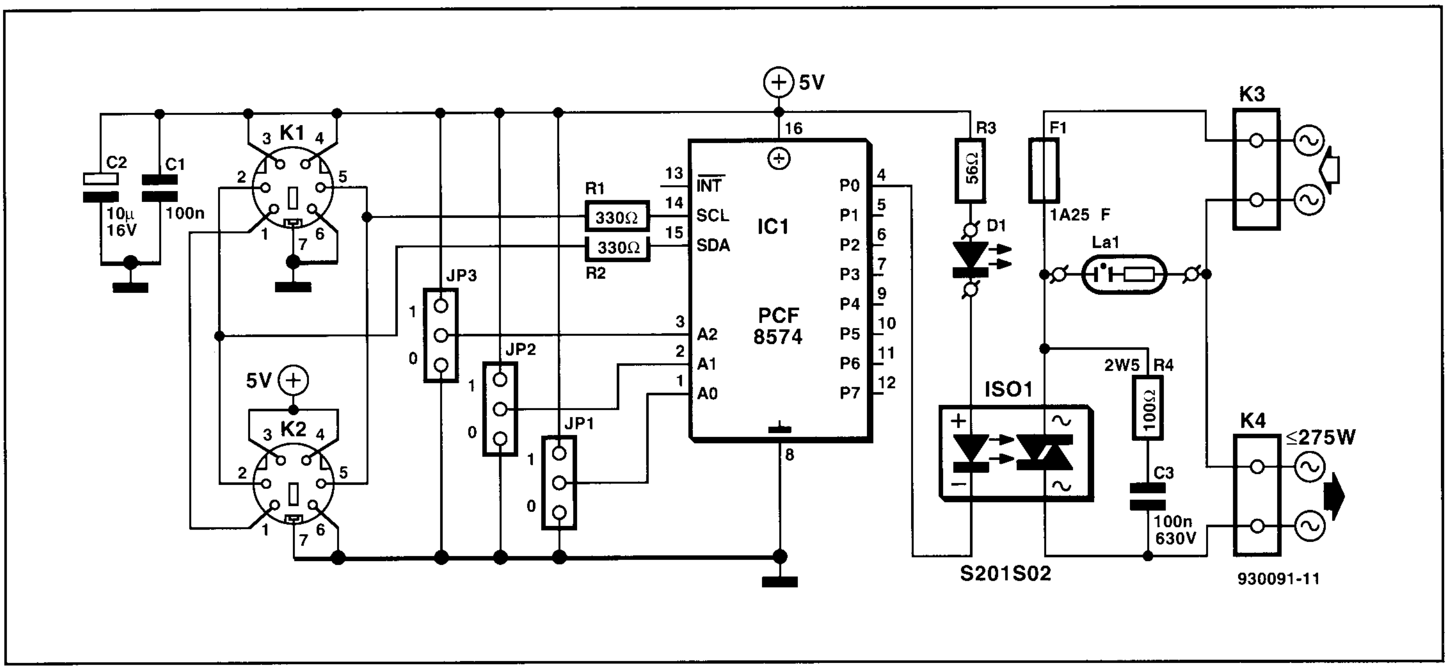


Fig. 1. Circuit diagram of the power switching module, which is driven via an I²C bus.

sists of R4 and C3, and serves to limit the voltage changes (d*U*/d*t*) across the triac. Without this network, there is a real chance of the triac starting to conduct spontaneously when fast voltage changes occur.

A neon lamp with built-in series resistor is connected across the *RC* network to indicate that the mains voltage is present in the module when it is plugged into a mains outlet. Fuse F1 is included to ensure that the current through the triac can not exceed 1.25 A. In this way, the triac is protected against overloading because the maximum continuous current through the solid-state relay is 1.5 A.

Al other components in the circuit are passive; two capacitors, C1 and C2, which decouple the supply voltage of IC1; resistors R1 and R2, which act as current limiters on the SDA and SDL lines; and three jumpers, JP1, JP2 and JP3, which are used to set the three least significant address bits.

From theory to practice

The copper track layout and the component positioning on the printed circuit board shown in **Fig. 2** afford a high degree of safety provided you work neatly and use the right components. Start the construction by cutting off the two corners and the notch in the PCB. Next, fit the four wire links on the board, and then the components. The neon lamp (LA1) is optional, and may be omitted. Set the jumpers to give the desired address. A '0' is selected when the jumper is at the side of the fuseholder, and a '1' when the jumper is at the side of the IC. To reduce the risk of touching the mains voltage while the circuit is not fitted into the enclosure, it is recommended to fit the plastic cap that comes with

CATCH THE I^2C BUS

The Philips I^2C bus offers an extremely simple way of interconnecting and controlling complex integrated circuits. A wide variety of I^2C bus compatible ICs is available, while prices of these devices are relatively low because of mass production to cater for the need of consumer electronics. *Elektor Electronics* has published a number of articles that describe the operation and practical application of I^2C compatible ICs, complete with suitable software for IBM PCs and compatibles. If you have not already done so, catch the I^2C bus with the following articles in *Elektor Electronics*:

Inter-IC communications	September 1990
Video digitizer	July/August 1991
I^2C interface for PCs	February 1992
I^2C LED display	June 1992
Speech/sound memory	December 1992
I^2C alphanumerical display	July/August 1993
I^2C bus fuse	July/August 1993
I^2C opto/relay card	February 1993

COMPONENTS LIST

Resistors:		
2	330Ω	R1;R2
1	56Ω	R3
1	100Ω 2W5	R4
Capacitors:		
1	100nF	C1
1	10µF 16V	C2
1	100nF 630V	C3
Semiconductors:		
1	green LED	D1
1	PCF8574(A)	IC1
Miscellaneous:		
2	PCB-mount 6-way mini-DIN socket	K1;K2
2	2-way PCB terminal block, pitch 7.5mm	K3;K4
1	S201S02 (Sharp)	ISO1
1	1A25 fast fuse with PCB mount holder	F1
1	Neon lamp with internal resistor for mains voltage	La1
1	Enclosure with moulded mains plug and socket; size approx.120 × 65 × 50 mm, e.g. Bopla SE432 DE	
1	Printed circuit board 930091 (see page 110)	

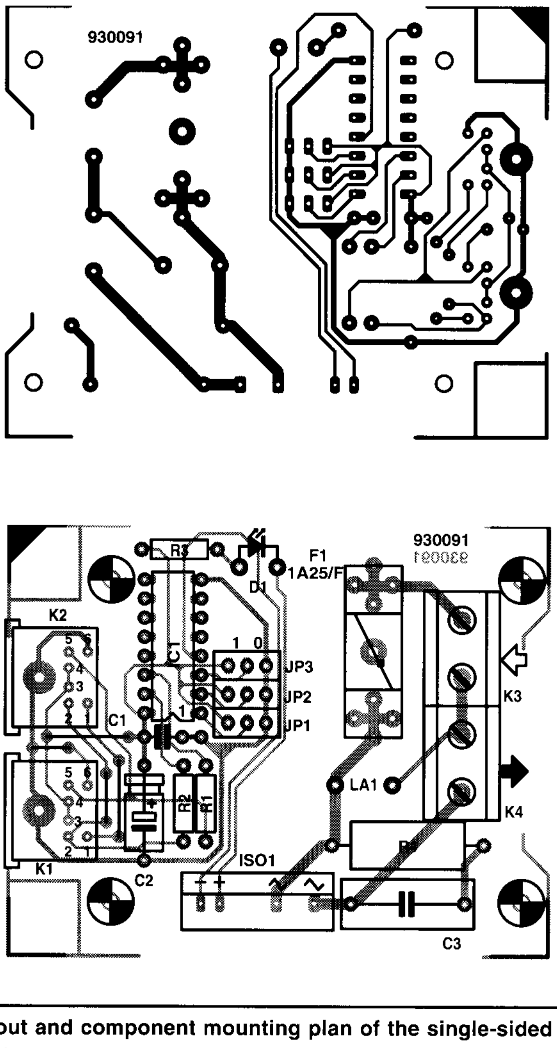


Fig. 2. Track layout and component mounting plan of the single-sided printed circuit board designed for the I^2C power switch.

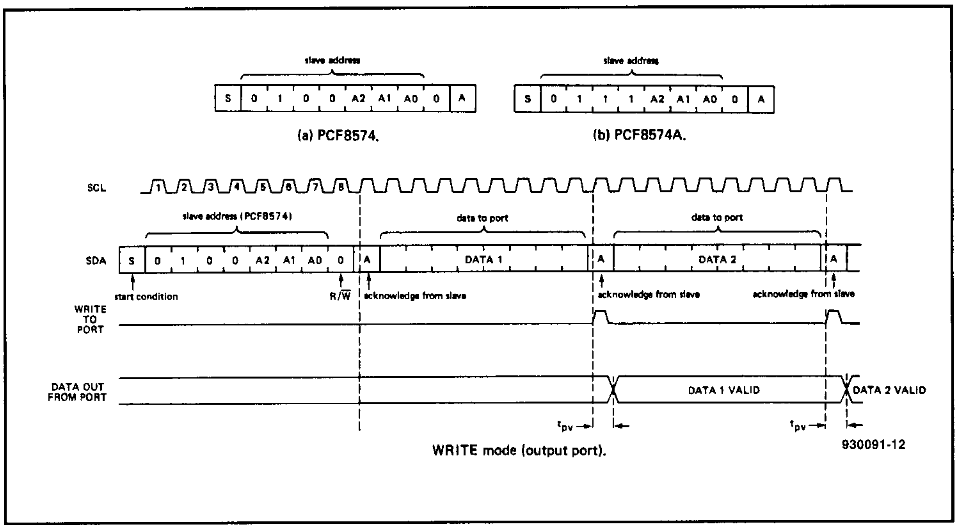


Fig. 3. Overview of data exchange between the PC and the I/O IC.

the PCB mount fuse holder.

Two holes are drilled in the mains adaptor enclosure to enable the DIN plugs to be inserted into the sockets on the board. Next, the PCB is secured into the enclosure with the aid of two screws. When the enclosure stated in the parts list is used, the two holes near the PCB terminal block may not be used for metal bolts. If you still want to fix the PCB at these locations, use nylon bolts instead.

Next, fit LED D1 into the cover of the case, and connect it to the PCB. Finally, connect the PCB to the integral plug pins and the socket terminals. Fit the cover onto the case, and secure the fixing screws. The circuit is then ready for testing.

One final remark on the electronic relay. The S210S02 contains a zero-crossing detector, and is only suitable for switching nonreactive loads. If you want to switch reactive loads also, use the S201S01, which switches randomly, and therefore does not cause problems with capacitive or inductive loads.

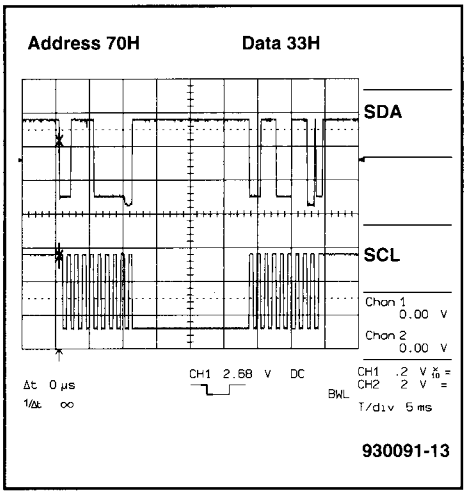


Fig. 4. This oscilloscope screendump clearly indicates the position of the acknowledge pulse. The signal level is not quite to specification because it is generated by the receiving IC.

Reading and writing

Once the hardware is finished, it is time to concentrate on the software. The base address of the PCF8574 is 40H, or 70H when the PCF8574A is used. The address set with the aid of the jumpers is added to this base address. Further, the LSB (least significant bit) determines the direction of the data: reading (1) or writing (0). Writing a logic 1 to an output bit causes the line to be switched to 'output'. If you wish to use a bit as an input, initialize it by writing a '1' to it. Once this is done, the relevant bit may be used as an input for the rest of the time.

Figure 3 shows the drive signals of the PCF8574 as reproduced from the Philips Semiconductors databook. The position of the jumpers is clearly seen in the address (JP1/JP2/JP3 = A2/A1/A0). A '0' for the eighth address bit indicates a write action to the IC, while a '1' indicates that data is read from the IC. The latter option is useful with regard to the I²C power switch because it allows the PC to interrogate the on/off status of the load. Writing 00H into the I/O port causes the load to be switched on, while writing 01H switches it off.

The digital oscilloscope screendump in **Fig. 4**, finally, shows a nice example of the signals present on the SDA and SCL lines during a write command to the IC. Since 330-Ω protection resistors were inserted in the lines during the measurement, the voltage level on the SDA line was strongly dependent on the transistor that happened to be switching at a particular instant. The advantage is that the acknowledge pulse is clearly discernible in the scope picture. The switching level is clearly different from that which arises when the computer is busy switching. This variation may come in handy during faultfinding: the closer you measure to the port that generates the acknowledge pulse, the closer the signal level is to the ground potential. ■

Reference:

1. I²C interface for PCs, *Elektor Electronics* February 1992.

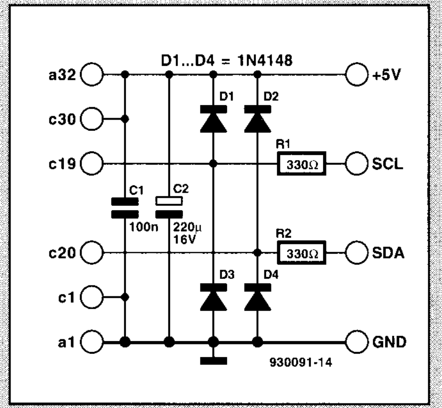
I²C ON THE ACORN PC

By virtue of the I²C interface on the podule bus, owners of an Acorn PC (also know as Acorn Archimedes) do not need a special insertion card to be able to use all the I²C application modules described in *Elektor Electronics*. What's more, all software needed to communicate with I²C devices is implemented in the Acorn operating system.

The circuit below shows how to connect the I²C modules to the Acorn PC. The SDA and SCL signals are on pins C20 and C19 respectively of the podule bus. The SWI called IIC_Control may be used to drive the hardware. Information on the use of this SWI in programs may be found on page 1-944 of the *RISC OS3 Programmer's Reference Manual*.

The resistors and diodes in the circuit protect the computer hardware against damage caused by errors during experimenting.

Users of the video digitizer (*Elektor Electronics* July/August 1991) may find the necessary signals directly on the podule, where the I²C bus is used to program I/O ports (PCF8574) and a DAC for picture intensity control (PCF8591). The fixing bracket of the podule will no doubt have some spare room to accommodate an extra mini-DIN socket. That is all there is to making an external I²C interface on the Archimedes.



Our thanks are due to Mr. J.P. Hendrix of Dongen, the Netherlands, for this useful tip.

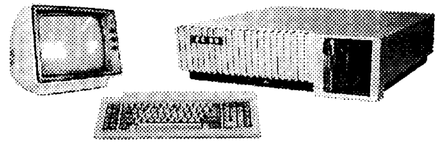
Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

LOW COST PC SPECIALISTS - ALL EXPANDABLE - ALL PC COMPATIBLE

8088 XT - PC99

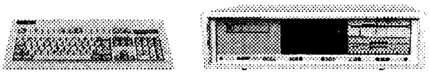


- **256k RAM - expandable to 640k**
- **4.7 Mhz speed**
- **360k 5-1/4" floppy**
- **2 serial & 1 parallel ports**
- **MS-DOS 4.01**
- **Factory burnt-in**
- **Standard 84 key keyboard**
- **12" green screen included**
- **In good used condition**

Optional FITTED extras: 640K RAM £39. 12" CGA colour monitor with card £39. 2nd 5-1/4" 360K floppy £29.95. 20 mbyte MFM hard drive £99.

Only £99.00 (F)

286 AT - PC286

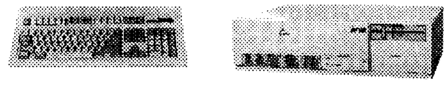


- **640k RAM expandable with standard SIMMS**
- **12 Mhz Landmark speed**
- **20 meg hard disk**
- **1.2 meg 5-1/4" floppy**
- **1.4 meg 3-1/2" floppy**
- **EGA driver on board**
- **2 serial & 1 parallel ports**
- **MS-DOS 4.01**
- **Co-processor socket**
- **Enhanced 102 key keyboard**
- **Clock & calendar with battery back up**

BRAND NEW AND BOXED!

Only £249.00 (F)

386 AT - PC386



- **2 meg RAM expanded by slots**
- **20 Mhz with 32k cache. Expandable to 64k**
- **40 meg hard disk**
- **1.2 meg 5-1/4" floppy**
- **VGA card installed**
- **2 serial & 1 parallel ports**
- **MS-DOS 4.01**
- **Co-processor socket**
- **Enhanced 102 keyboard**
- **Kwik Disk Accelerator Software - FREE**

BRAND NEW AND BOXED!

Only £425.00 (F)

FLOPPY DISK DRIVES

5¼" from £22.95 - 3½" from £21.95!

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported).

3.5" Panasonic JU363/4 720K or equivalent	**£29.95**(B)
3.5" Mitsubishi MF355C-L. 1.4 Meg. Laptops only*	**£29.95**(B)
3.5" Mitsubishi MF355C-D. 1.4 Meg. Non laptop	**£29.95**(B)
5.25" EXTRA SPECIAL BRAND NEW Mitsubishi MF501B 360K. Absolutely standard fits most computers	**£22.95**(B)

*** Data cable included in price.**

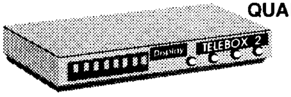
Shugart 800/801 SS refurbished & tested	**£175.00**(E)
Shugart 851 double sided refurbished & tested	**£275.00**(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW	**£250.00**(E)

Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! **£499.00**(F)

End of line purchase scoop! Brand new **NEC D2246** 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only......................**£299**(E)

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER!

The TELEBOX consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD and many more. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television or video channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Composite and RGB video outputs are located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

Telebox ST	for composite video input monitors	**£32.95**
Telebox STL	as ST but with integral speaker	**£36.50**
Telebox MB	as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification.	**£69.95**
Telebox RGB	for analogue RGB monitors (15khz)	**£69.95**

Shipping code on all Teleboxes is (B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM / NTSC not available.

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals...........**MUK......£249** (F) **MUD......£525** (G)

The Philips 9CM073 is suggested for the PC286 and the CM8873 for the PC386. Either may use the SVGA MTS-9600 if a suitable card is installed. We can fit this at a cost of £49.00 for the PC286 and £39.00 for the PC386.

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak).Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims13" x 5" x 2.5". Fully guaranteed RFE.	**£85.00** (B)
Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ± 12v @ 1.5A. Switch mode. New.	**£59.95**(B)
Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4".New	**£22.95**(B)
Greendale 19AB0E 60 watts switch mode.+5v @ 6a,±12v @ 1a,+15v @ 1a. RFE and fully tested.11 x 20 x5.5cms.	**£24.95**(C)
Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms.New.	**£49.95**(C)
Boshert 13090.Switch mode.Ideal for drives & system. +5v@ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a.	**£29.95**(B)
Farnell G6/40A. Switch mode. 5v @ 40a.Encased	**£95.00**(C)
Farnell G24/5S. As above but 24v @ 5a.	**£65.00**(C)

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

BBC Model B type computer on a board. A major purchase allows us to offer you the **PROFESSIONAL** version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and ± 12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data, On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only £29.95 or 2 for £53 (B)

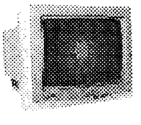
SPECIAL INTEREST

Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Anton Pillar 400 Hz 3 phase frequency converter 75Kw	POA
Newton Derby 400 Hz 70 Kw converter	POA
Nikon PL-2 Projection lens meter/scope	£750
Sekonic SD 150H 18 channel Hybrid recorder	£2000
HP 7580A A1 8 pen high speed drum plotter	£1850
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

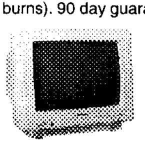
BRAND NEW PRINTERS

Microline 183. NLQ 17x17 dot matrix. Full width.	**£139** (D)
Hyundai HDP-920. NLQ 24x18 dot matrix full width.	**£149** (D)
Qume LetterPro 20 daisy. Qume QS-3 interface.	**£39.95** (D)
Centronics 152-2 9 x 7 dot matrix. Full width.	**£149** (D)
Centronics 159-4 9 x 7 dot matrix.Serial. 9-1/2" width	**£ 99** (D)

MONITORS

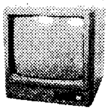


14" Forefront Model MTS-9600 SVGA multisync with resolution of 1024 x 768. 0.28 pitch. "Text" switch for word processing etc. Overscan switch included. Ideal for the PC-386 or PC-286 with SVGA card added. Also compatibe with BBC, Amiga, Atari (including the monochrome high resolution mode), Archimedes etc. In good used condition (possible minor screen burns). 90 day guarantee. 15" x 14" x 12". Only............**£159**(E)



14" Philips Model CM8873 VGA multisync with 640 x 480 resolution. CGA, EGA or VGA, digital/analog, switch selectable. Sound with volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with IBM PC's, Amiga, Atari (excluding the monochrome high resolution mode), BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only ....**£139**(E)

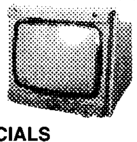
Philips 9CM073 similar (not identical) to above for **EGA/CGA** PC and compats. 640 x 350 resolution. With Text switch with amber or green screen selection. 14" x 12" x 13-1/2"........**£99**(E)



KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also works as quality TV with our RGB Telebox. Good used condition. 90 day guarantee. Only..**£125** (E)

KME as above for PC EGA standard........................£145 (E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case.Full 90 day guarantee. Only .... **£129** (E)



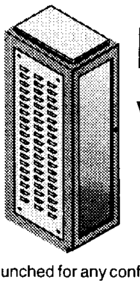
NEC CGA 12" IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for contractual reasons. Only......... **£69** (E)

20", 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools,Shops,Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

CALL FOR PRICING ON NTSC VERSIONS!



Superb Quality 6 foot 40u

19" Rack Cabinets

Massive Reductions

Virtually New, Ultra Smart!

Less Than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1 Complete with removable side panels.......	**£275.00** (G)
Rack 2 Less side panels	**£145.00** (G)

1992 Winter Issue of *Display News* now available - send large SAE - PACKED with bargains!

DISPLAY -ELECTRONICS-

MAIL ORDER & OFFICES
Open Mon-Fri 9.00-5.30
Dept EL, 32 Biggin Way,
Upper Norwood,
London SE19 3XF.

LONDON SHOP
Open Mon-Sat 9-5.30
Thursday till 9.00pm
215 Whitehorse Lane,
South Norwood,
London, SE25 .

DISTEL © The Original
Free dial-up database!
1000's of items+info on line
V21, V22 & V22 bis
081-679-1888

ALL ENQUIRIES
081-679-4414
Fax- 081-679-1927

Access Visa

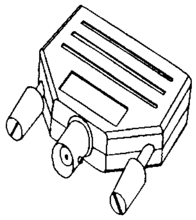
All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. PO orders from Government,Universities,Schools & Local Authorities welcome-minimum account order £30. Carriage charges (A)=£2.00. (A1)=£3.75. (B)=£5.50. (C)=£8.50. (D)=£11.50. (E)=£14.00 (F)=£18.00 (G)=Call . Scotland surcharge: call. All goods supplied subject to our standard Conditions of Sale and unless otherwise stated guaranteed for 90 days. All guarantees on a return to base basis.Rights reserved to change prices & specifications without prior notice. Orders subject to stock. Quotations willingly given for higher quantities than those stated. Bulk surplus always wanted for cash.

Low cost data acquisition for IBM PCs & compatibles...

A unique range of low cost data acquisition products for IBM PCs and compatibles. Installed in seconds they simply plug directly into either the serial or parallel port. They are completely self contained, require no external power supply and take up no expansion slots.

Each device comes with an easy to use software package (PicoScope, PicoLog or both). C, Pascal, and Basic drivers are supplied for those who want to develop their own software, as is a manual giving full details of the hardware and software. All software supplied on 3.5" disk.

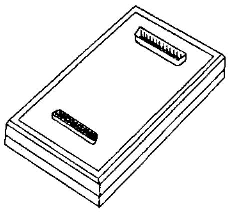
ADC-10



- Up to 24kHz sampling rate from a 386/33MHz machine
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes PicoScope software

Single Channel 8 bit ADC £49

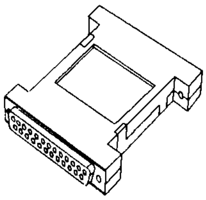
ADC-16



- Software selectable single ended or differential inputs
- Resolution programmable between 8 and 16 bits + sign
- ±2.5V input range
- 5V reference output
- Connects to serial port
- Includes PicoLog software

8 Channel 16 bit + sign ADC £99

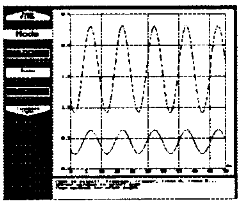
ADC-11



- 15K samples per second
- 0-2.5V Input range
- Digital output
- D25 input connector
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

11 Channel 10 bit ADC £75

PicoScope

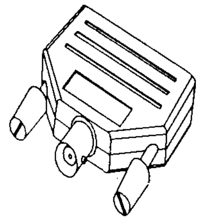


Scope, voltmeter, spectrum analyser

'Virtual instrument' software package for the ADC-10, ADC-11 and ADC-12.

Storage oscilloscope with trigger and timebase. Traces can be printed and saved. Multiple meters on screen. Real time spectrum analysis.

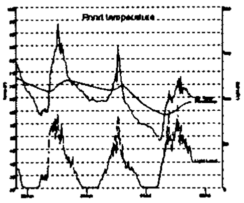
ADC-12



- Up to 18kHz sampling rate
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

Single Channel 12 bit ADC £85

PicoLog



Advanced data logging software

Collect samples from 1 per ms to one per day. Scale samples linearly, by equation or by table look-up. Graphical (against time or XY) and text reports can be displayed, printed or exported.

Picolog is also available for the ADC-10 : call for details.

Typical application	ADC-10	ADC-11	ADC-12	ADC-16
Oscilloscope	●	●	●	
Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●		●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Chromatography				●
Automotive monitoring		●		●
Medical research		●	●	●
Education	●	●	●	●

PICO BENEFITS

- 30 day no quibble money back policy
- Full 1 year guarantee
- 1 year's free software upgrades
- Free technical support
- Free user newsletter
- Same day dispatch

PICO TECHNOLOGY

Pico Technology Ltd. Broadway House, 149 -151 St Neots Road, Hardwick, Cambridge. CB3 7QJ.

TEL: 0954-211716 FAX: 0954-211880

Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT.

ELEKTOR ELECTRONICS CUMULATIVE INDEX 1993

Notation:
article title ... [month — page number]
Example: [9 — 41] = September 1993, page 41.

APPLICATION NOTES

IR receiver/demodulator SFH505A ... 7/8 — 104
Programmable sine wave generators ML2035/2036 ... 10 — 40

AUDIO AND HI-FI

Active 3-way loudspeaker — 1 ... 7/8 — 8
Active 3-way loudspeaker — 2 ... 9 — 44
Active bass correction ... 7/8 — 81
Camcorder audio mixer ... 7/8 — 96
Class-A preamplifier ... 7/8 — 61
Cross-over point detector ... 1 — 28
Digital-audio enhancer ... 2 — 32
Digital output for CD players ... 9 — 61
Fourth-order single-chip filter ... 7/8 — 66
Low-noise microphone amplifier ... 7/8 — 46
Medium-power HEXFET amplifier ... 12 — 8
Open-baffle loudspeaker ... 4 — 20
Output amplifier with AF band-pass filter ... 11 — 34
Peak level indicator ... 12 — 45
Philips preamplifier ... 4 — 52
Solid-state voice recorder ... 12 — 36
Special band-stop filter ... 12 — 52
Spectrum VU meter ... 6 — 8
Stereo mixer ... 10 — 44
Stereo PWM output amplifier ... 12 — 38
Voice-operated recording ... 7/8 — 36

COMPUTERS AND MICROPROCESSORS

4 Mbyte printer buffer insertion card — 1 ... 3 — 20
4 Mbyte printer buffer insertion card — 2 ... 4 — 54
8-channel A-D converter ... 12 — 76
80C32 computer application notes:
  DTMF decoder ... 3 — 40
  TV test pattern generator ... 3 — 42
  RC5 code generator ... 4 — 66
  Windscreen wiper control ... 4 — 67
  X2404 EEPROM interfacing to an 8751 ... 6 — 64
535 card with EPROM emulator - 1 ... 11 — 30
535 card with EPROM emulator - 2 ... 12 — 16
Compact A-D converter ... 12 — 54
Copying in MS-DOS with one drive ... 7/8 — 34
Electrically isolated RS232 interface ... 3 — 52
Extended PC drive LED ... 7/8 — 43
Hexadecimal display decoder ... 12 — 74
I^{2}C alphanumerical display ... 7/8 — 8
I^{2}C bus fuse ... 7/8 — 62
I^{2}C EEPROM ... 12 — 34
I^{2}C opto/relay card ... 2 — 64
I^{2}C power switch ... 12 — 101
I^{2}C tip ... 7/8 — 42
Infra-red receiver for 80C32 SBC ... 4 — 48
Joystick converter for PCs ... 7/8 — 50
Microcontroller-driven UART ... 12 — 80
Precision clock for PCs ... 11 — 24
RC5 infra-red receiver for 80C32 ... 12 — 52
Real-time clock for 80C32 computer ... 6 — 45
ROM gate switch-over for Atari ST ... 10 — 58
Speed indicator for PCs ... 7/8 — 72
SCSI active termination ... 7/8 — 63
Video digitizer ... 4 — 32

COMPONENTS

GAL programmer upgrade ... 6 — 28
GAL programmer software for Amiga ... 6 — 31

DESIGN IDEAS

Isolation amplifiers ... 1 — 59
A progressive and holistic design for an economical soundwall ... 5 — 44
Simple, low-cost antenna test instruments — 1 ... 3 — 65
Simple, low-cost antenna test instruments — 2 ... 4 — 62
Temperature-insensitive voltage divider ... 4 — 52

ELECTRONICS AND MUSIC

Harmonics enhancer ... 7/8 — 14
MIDI channel monitor ... 10 — 64

GENERAL INTEREST

Active two-wire temperature sensor ... 12 — 36
The analogue subsystem — 1 ... 7/8 — 100
The analogue subsystem — 2 ... 9 — 64
The analogue subsystem — 3 ... 11 — 55
Angler's bait indicator ... 12 — 56
Automatic twilight switch ... 12 — 64
BASIC timer I ... 12 — 64
BASIC timer I ... 12 — 70
Bicycle light with afterglow ... 12 — 32
Car interior light delay ... 12 — 60
Car lights whistle blower ... 1 — 67
Complementary doorbell ... 12 — 73
Cooking timer ... 1 — 64
DC motor regulator ... 7/8 — 52
Digital audio-visual system — 3 ... 1 — 49
Digital audio-visual system — 4 ... 2 — 52
Electromagnetic compatibility — 1 ... 5 — 24
Electromagnetic compatibility — 2 ... 6 — 50
Electronic bell-push ... 12 — 65
Figuring it out — Part 1 ... 1 — 14
Figuring it out — Part 2 ... 2 — 22
Figuring it out — Part 3 ... 3 — 32
Figuring it out — Part 4 ... 4 — 28
Figuring it out — Part 5 ... 5 — 41
Figuring it out — Part 6 ... 6 — 24
Figuring it out — Part 7 ... 7/8 — 26
Figuring it out — Part 8 ... 9 — 50
Figuring it out — Part 9 ... 10 — 48
Figuring it out — Part 10 ... 11 — 40
Figuring it out — Part 11 ... 12 — 84
Fog light switching ... 7/8 — 45
Four-fold digital-to-analogue converter ... 7/8 — 14
Frequency-operated switch ... 12 — 30
General-purpose Schmitt trigger ... 7/8 — 67
General transformer PCB ... 7/8 — 51
Halogen light switch ... 7/8 — 66
Interior light switch for cars ... 7/8 — 68
Light switch for motorcycles ... 7/8 — 35
Long-duration timer ... 12 — 65
Low-drop a.c. switch ... 12 — 40
Make your own PCBs ... 7/8 — 99
Making sense of measurements — 1 ... 5 — 28
Making sense of measurements — 2 ... 6 — 40
Matrix key pad ... 7/8 — 60
Maxi micro clock ... 7/8 — 90
Mini micro clock ... 9 — 70
Multi-colour LED ... 12 — 56
Multi-purpose display decoder ... 7/8 — 76
Optical squelch ... 12 — 39
PCB drill control ... 12 — 68
Photographic workshop light ... 12 — 88
Plant humidity monitor ... 7/8 — 108
Power booster for slide projectors ... 12 — 77
Precedence detector ... 12 — 49
Privacy phone ... 12 — 42
PWM motor control ... 12 — 30
Sequential touch switch ... 7/8 — 39
Single-chip temperature control ... 7/8 — 42
SMD soldering station ... 7/8 — 5

Speed-chess clock .... 7/8 — 47
Telephone controlled night light .... 7/8 — 38
Telephone monitor .... 12 — 60
Temperature monitor .... 12 — 50
Thyristor starter for fluorescent tubes .... 1 — 67
Two-way indicator light .... 7/8 — 33
Variable differential amplifier .... 12 — 50
Virtual ground .... 7/8 — 32
Wind direction indicator .... 12 — 48
Windscreen wiper control .... 12 — 31

POWER SUPPLIES AND BATTERY CHARGERS

U2400B NiCd battery charger .... 2 — 40
Ah meter with digital display .... 10 — 16
Automatic power-off .... 7/8 — 40
Battery charging regulator .... 12 — 54
Battery discharger .... 12 — 77
Battery voltage monitor .... 12 — 78
Button cell charger .... 12 — 42
Car battery voltage monitors .... 7/8 — 70
DC-DC converter .... 7/8 — 48
Electronic fuse .... 7/8 — 80
Electronic load .... 11 — 5
Fast active rectifier .... 7/8 — 68
Fast high-power zener diode .... 7/8 — 56
Inexpensive voltage doubler .... 12 — 70
Lead-acid battery charger .... 7/8 — 84
Microcontroller-driven NiCd battery charger .... 10 — 30
NiMH battery charger .... 12 — 78
Regulator output delay .... 7/8 — 56
Regulator short-circuit indicator .... 12 — 48
Simple d.c. to d.c. converter .... 12 — 46
Small power converter .... 12 — 35
Solar panel switch .... 12 — 32
State of battery indicator .... 7/8 — 32
Symmetrical power supply .... 12 — 72
Views of the bridge - Part 1 .... 12 — 20
Workbench power supply unit .... 5 — 32
Zener bridge .... 7/8 — 62

RADIO, TELEVISION AND COMMUNICATIONS

27 MHz AM/FM transmitter .... 4 — 14
950-1750 MHz converter .... 9 — 20
A CW compatible T/R switch .... 6 — 56
Basic infra-red transmitter .... 12 — 45
Choosing component values for *LC* resonant circuits .... 12 — 96
Digital read-out for VHF/UHF receiver .... 6 — 34
Dual video amplifier .... 1 — 36
DX television .... 2 — 50
DX television .... 4 — 60
DX television .... 6 — 62
DX television .... 9 — 74
DX television .... 11 — 60
An experimental HF ferrite loop transmitting antenna .... 3 — 14
External ferrite aerial units for short, medium and long-wave radios .... 5 — 46
Ferguson BSB receiver as D2MAC decoder .... 7/8 — 44
Frequency doubler .... 12 — 46
Inexpensive video enhancer .... 12 — 63
Infra-red AF receiver .... 7/8 — 54
Infra-red AF transmitter .... 7/8 — 54
Infra-red controlled remote switch .... 12 — 44
Low-power NBFM transmitter .... 12 — 62
Multi-user satellite TV reception .... 2 — 8
Output amplifier with AF band-pass filter .... 11 — 34
Radio data system (RDS) decoder .... 5 — 8
RF attenuators .... 2 — 26
RFi screening .... 1 — 68
SCART switching box .... 12 — 92
Simple, low-cost antenna test instruments — 1 .... 3 — 65
UHF remote control receiver .... 7/8 — 54
UHF remote control transmitter .... 7/8 — 54
VHF-low converter .... 7/8 — 20
VHF/UHF receiver .... 5 — 62
VHF/UHF television tuner — 1 .... 10 — 8
VHF/UHF television tuner — 2 .... 11 — 10
Video data change detector .... 12 — 72
Video digitizer .... 4 — 32
World band radio .... 3 — 59

SCIENCE AND TECHNOLOGY

Convolutional and block codes for multiple error detection .... 1 — 43
Electricity from the wind .... 6 — 14
EMC testing of PMR equipment .... 7/8 — 86
A sinusoidal alternative: wave sine wave generators a goodbye ... 3 — 36
A possible mechanism for the effects of electromagnetic fields on biological cells .... 2 — 46
Wideband wireless data systems .... 4 — 40

TEST AND MEASUREMENT

1.2 GHz multifunction frequency meter — 2 .... 1 — 30
1.2 GHz multifunction frequency meter — 3 .... 2 — 67
1.2 GHz multifunction frequency meter — 4 .... 3 — 45
Active probe .... 7/8 — 106
Ah meter with digital display .... 10 — 16
Audible continuity tester .... 7/8 — 74
Audible tester .... 7/8 — 40
Audible transistor tester .... 7/8 — 30
Audio power meter .... 4 — 8
Autoranging frequency readout .... 10 — 52
Continuity tester .... 7/8 — 73
Digital hygrometer .... 11 — 18
FM stereo signal generator .... 5 — 16
Fuzzy logic multimeter — 1 .... 9 — 36
Fuzzy logic multimeter — 2 .... 10 — 22
Fuzzy logic multimeter — 3 .... 11 — 62
General-purpose digital tester .... 7/8 — 45
Inexpensive phase meter .... 6 — 19
Linear sound pressure meter .... 3 — 8
Linear temperature gauge .... 9 — 29
Logic level tester .... 7/8 — 80
Multicore cable tester .... 1 — 20
Multifunction test probe .... 7/8 — 52
Multiphase rectangular wave generator .... 7/8 — 78
PAL test pattern generator .... 1 — 8
PC aided transistor tester .... 9 — 54
Power MOSFET tester .... 11 — 46
RMS AF voltmeter .... 12 — 24
Storage oscilloscope tester .... 12 — 73
Triangular signal generator .... 7/8 — 55
Watt-hour meter — 1 .... 2 — 14
Watt-hour meter — 2 .... 3 — 26

CORRECTIONS AND UPDATES

1.2 GHz multifunction frequency meter (12/1992) .... 9 — 73
U2400B NiCd battery charger (2/1993) .... 7/8 — 18
4-MByte printer buffer insertion card for PCs (4/1993) .... 5 — 26
Audio DAC (9/1992) .... 7/8 — 18
Digital audio/visual system (Multipurpose Z80 card) (5-6/1992) .... 7/8 — 18
FM stereo signal generator (5/1993) .... 7/8 — 18
I²C interface for PCs (2/1992) .... 9 — 73
LFA150-A Class-A amplifier (11-12/1991) .... 1 — 46
Real-time clock for 80C32 computer (6/1993) .... 9 — 73
Sound sampler for Amiga (11/1991) .... 1 — 46
VHF-low converter (6/1993) .... 9 — 73
VHF/UHF receiver (5/1993) .... 7/8 — 18
Workbench PSU (5/1993) .... 7/8 — 18

PRODUCT OVERVIEW

DECEMBER 1993

A number of projects carried in *Elektor Electronics* are supported by ready-made printed-circuit boards (PCBs), self-adhesive front panel foils, ROMs, EPROMs, PALs, GALs, microcontrollers and diskettes, which may be ordered through our Readers Services using the order form printed every month opposite the Readers Services page.

The list printed here is complementary to the shorter one opposite the Readers Services page elsewhere in this issue. This two-page overview of all currently available products is regularly updated and appears in the March, June, September and December issues of *Elektor Electronics*.

Items marked with a dot (●) following the product number are in limited supply only, and their availability can not be guaranteed by the time your order is received.

Items not listed here or on this month's Readers Services page are not available.

The artwork for making PCBs which are not available ready-made through the Readers Services may be found in the relevant article (from March 1990 onwards).

Prices and item descriptions subject to change. Prices can be confirmed on request at the time of ordering.

PRINTED-CIRCUIT BOARDS

1987

Project	No.	Price	
		(£)	(US$)
JANUARY 1987			
Top-of-the-range preamplifier	86111-2 ●	26.45	52.90
FEBRUARY 1987			
Electron ROM card	86089 ●	6.70	13.40
MARCH 1987			
MSX EPROMmer	87002 ●	11.15	22.30
APRIL 1987			
Facsimile interface	87038 ●	10.40	20.80
MAY 1987			
MIDI signal distribution	87012 ●	8.70	17.40
OCTOBER 1987			
Low-noise microphone preamplifier	87058 ●	4.05	8.10
NOVEMBER 1987			
BASIC computer	87192	23.80	47.60
Dimmer for inductive loads	87181 ●	7.05	14.10

1988

Project	No.	Price	
		(£)	(US$)
JANUARY 1988			
Stereo limiter	87168 ●	8.50	17.00
FEBRUARY 1988			
Infra-red headphones	87640 ●	7.20	14.40
MARCH 1988			
Computer-controlled slide fader	87259 ●	18.80	37.60
Low-noise preamplifier for FM receivers	880041 ●	7.65	15.30
Signal divider for satellite TV receivers	880067 ●	5.90	11.80
APRIL 1988			
Fuzz unit for guitars	87255 ●	7.65	15.30
Active loudspeaker system	880030 ●	8.80	17.60
MAY 1988			
Plotter	87167 ●	13.50	27.00
JUNE 1988			
Wideband active aerial	880043-1 ●	7.05	14.10
for SW receivers	880043-2 ●	5.60	11.20
JULY/AUGUST 1988			
Frequency read-out for SW receivers	880039 ●	21.60	43.20
OCTOBER 1988			
Centronics interface for slide fader	880111 ●	9.10	18.20
Preamplifier for	880132-1 ●	6.95	13.90
purists	880132-2 ●	14.40	28.80
Peripheral modules for BASIC computer	880159 ●	5.90	11.80
NOVEMBER 1988			
Bus interface for hi-res LCD screens	880074 ●	19.70	39.40
LFA-150 — a fast	880092-1 ●	9.95	19.90
power amplifier	880092-2 ●	9.20	18.40
Harmonic enhancer	880167 ●	7.40	14.80
Portable MIDI keyboard	880168 ●	9.20	18.40
DECEMBER 1988			
LFA-150 — a fast	880092-3 ●	7.50	15.00
power amplifier	880092-4 ●	7.60	15.20
CVBS-to-TTL adaptor	880098 ●	5.70	11.40
Autonomous I/O controller	880184 ●	18.00	36.00

1989

Project	No.	Price	
		(£)	(US$)
JANUARY 1989			
Fax interface for Atari ST and Archimedes	880109	8.65	17.30
MIDI control unit	880178-1	10.65	21.30
	880178-2	7.80	15.60
Low-budget capacitance meter	UPBS-1	2.30	4.60
FEBRUARY 1989			
Digital Model Train	87291-1	4.95	9.90
Touch key organ	886077	11.80	23.60
VHF receiver	886127	8.75	17.50
MARCH 1989			
Power line modem	880189	7.15	14.30
Centronics buffer	890007-1	23.05	46.10
	890007-2	2.55	5.10
	890007-3	9.80	19.60
APRIL 1989			
Digital Model Train	87291-2/3	5.05	10.10
Function generator	UPBS-1	2.30	4.60
Triplet	890013-1	7.80	15.60
	890013-2	8.00	16.00
Multi-point IR control	890019-1	4.05	8.10
	890019-2	4.75	9.50
Video recording amplifier		ELV project	
MAY 1989			
RDS decoder	880209 ●	5.30	10.60
Digital Model Train (4)	87291-4	6.15	12.30
Analogue multimeter	890035	14.70	29.40
DTMF system decoder	890060	7.65	15.30
Sine-wave converter	UPBS-1	2.30	4.60
S-VHS-to-RGB converter		ELV project	
JUNE 1989			
8-digit frequency meter	880128	13.50	27.00
Echo unit		ELV project	
JULY/AUGUST 1989			
MIDI keyboard interface			
decoder board	890105-1	8.25	16.50
controller board			
Tracking tester		ELV project	
Floppy disk monitor	890078	5.00	10.00
Function generator	UPBS-1	2.30	4.60
SEPTEMBER 1989			
Digital Model Train	87291-6	7.85	15.70
Stereo viewer	890044	6.55	13.10
Resonance meter	886071	4.60	9.20
OCTOBER 1989			
Logic analyser with Atari ST	890126	6.15	12.30
CD error detector	890131	7.05	14.10
RGB-to-CVBS converter		ELV project	
NOVEMBER 1989			
Digital Model Train (8)	87291-5	51.10	102.20
DECEMBER 1989			
Digital Model Train	87291-7	10.30	20.60
EPROM simulator	890166	11.75	23.50
Hard disk monitor	890186	12.95	25.90
IC tester		ELV project	
LF/HF signal tracer	890183	9.40	18.80
Solid-state preamp	890170-1*	13.80	27.60
	890170-3*	10.60	21.20

1990

Project	No.	Price	
		(£)	(US$)
JANUARY 1990			
Video mixer (1)	87304-1	32.00	64.00
Mini EPROM programmer	890164	8.25	16.50
All solid-state preamplifier	890170-2*	18.50	37.00
Simple AC millivoltmeter	900004 ●	7.65	15.30

*The four PCBs required for the preamplifier (2 × 890170-1; 1× 890170-2 and 1× 890170-3) are available as a package, ref. 890170-9, at a discounted price of £48.15 (US$96.30).

Project	No.	Price	
		(£)	(US$)
FEBRUARY 1990			
Initialisation aid for printers	900007	16.75	33.50
Digital Model Train (11)	87291-8	5.30	10.60
Reflex MW AM receiver	UPBS-1	2.30	4.60
Video mixer (2)	87304-2	19.10	38.20
Capacitance meter	900012 ●	8.50	17.00
MARCH 1990			
Audio/video modulator		ELV project	
Digital model train (12)	87291-9	4.10	8.20
IC monitor	896140	8.80	17.60
Power line monitor	900025 ●	5.60	11.20
Video mixer (3)	87304-3	41.70	83.40
APRIL 1990			
Digital model train (13)	87291-10	4.70	9.40
Q meter	900031 ●	7.05	14.10
RS-232 splitter	900017-1	8.50	17.00
	900017-2	5.30	10.60
Wiring allocation tester		ELV project	
MAY 1990			
Acoustic temperature monitor	UPBS-1	2.30	4.60
Budget sweep/function generator	900040 ●	8.25	16.50
Centronics ADC/DAC	900037D	17.90	35.80
PC servicing card		ELV project	
Transistor characteristic plotting	900058	5.60	11.20
JUNE 1990			
Electronic load simulator	900042 ●	14.10	28.20
MIDI master keyboard	Doepfer Elektronik		
Mini EPROM viewer	900030	21.15	42.30
Power zener diode	UPBS-1	2.30	4.60
Remotely controlled stroboscope		ELV project	
JULY/AUGUST 1990			
Battery tester		ELV project	
Compact 10A power supply	900045	13.50	27.00
Intermediate projects	UPBS-1	2.30	4.60
Mini FM transmitter*	896118	5.00	10.00
Sound demodulator for satellite-TV receivers	900057	4.40	8.80
Audio power indicator	904004 ●	4.40	8.80
Four-monitor driver for PCs	904067 ●	6.15	12.30

* can not be supplied to readers in the UK

Project	No.	Price	
		(£)	(US$)
SEPTEMBER 1990			
High-current h_{FE} tester	900078 ●	6.45	12.90
Infra-red remote control	904085/86	7.95	15.90
Sound generator		ELV project	
OCTOBER 1990			
µP-controlled telephone exchange	900081	21.15	42.30
S-VHS/CVBS-to-RGB converter	900055 ●	14.40	28.80
NOVEMBER 1990			
400-watt laboratory PSU	900082 ●	12.95	25.90
Dubbing mixer EV7000		ELV project	
Medium-power audio amplifier	900098	10.60	21.20
Programmer for the 8751	900100	8.25	16.50
PT100 thermometer	900106 ●	5.90	11.80
DECEMBER 1990			
Active mini subwoofer	900122-2 ●	6.15	12.30
Milliohmmeter	910004 ●	5.90	11.80
Phase check for audio systems	900114-1/2 ●	9.40	18.80
PC-controlled Videotext decoder (1)		ELV project	
Signal suppressor for all-solid state preamp	904024 ●	4.40	8.80

1991

Project	No.	Price	
		(£)	(US$)
JANUARY 1991			
Logic analyser (1):			
- Busboard	900094-4 ●	10.60	21.20
PC controlled Videotext decoder (2)		ELV project	
SWR meter	900013	3.55	7.10
FEBRUARY 1991			
Logic analyser (2):			
- RAM board	900094-2 ●	18.50	37.00
- Probe board	900094-3 ●	5.00	10.00
Multifunction measurement card for PCs	900124-1	28.20	56.40
MIDI-to-CV interface	Doepfer Elektronik		
RDS decoder:			
- demodulator board	880209 ●	5.30	10.60
- processor board	900060 ●	7.65	15.30
MARCH 1991			
The complete preamplifier:			
- input board	890169-1	26.10	52.20
- main board	890169-2	39.35	78.70
Electronic exposure timer	900041 ●	10.85	21.70
PC-controlled weather station (1)	900124-3	4.40	8.80
2-m band converter	900006-1	5.00	10.00
APRIL 1991			
Logic analyser (3):			
- control board	900094-5 ●	18.50	37.00
MIDI programme changer	900138 ●	6.75	13.50
8-bit I/O for Atari	910005	12.35	24.70
6-m band transverter	910010	11.45	22.90
Wattmeter:			
- meter board	910011-1	6.45	12.90
- display board	910011-2	4.10	8.20
Moving-coil (MC) preamplifier	910016 ●	10.60	21.20
Dimmer for halogen lights:			
- transmitter	910032-1 ●	4.10	8.20
- receiver	910032-2 ●	4.40	8.80
PC-controlled semiconductor tester		ELV project	
MAY 1991			
80C32/8052 Computer	910042	12.05	24.10
Battery tester	906056	4.10	8.20
Laser (1)		ELV project	
Moving-magnet (MM) preamplifier	900111 ●	6.75	13.50
Universal I/O interface for IBM PCs	910046	10.85	21.70
JUNE 1991			
Universal battery charger	900134	9.40	18.80
Logic analyser - 4			
- power supply board	900094-7 ●	8.80	17.60
- Atari interface	900094-6 ●	12.65	25.30
- IBM interface	900094-1 ●	14.40	28.80
Digital phase meter (set of 3 PCBs)	910045-1/2/3	26.15	52.30
Light transceiver	UPBS-1	2.30	4.60
Variable AC PSU	900104 ●	6.15	12.30
Light switch w. TV IR r/c	910048	5.60	11.20
RTC for Atari ST	910006	6.15	12.30
JULY/AUGUST 1991			
Multifunction I/O for PCs	910029	24.40	48.80
B/W video digitizer	910053	22.60	45.20
Stepper motor board - 2:			
- power driver board	910054-2	28.50	57.00
Laser - 3		ELV project	
LED voltmeter	914005 ●	5.60	11.20
Wien bridge	914007 ●	4.10	8.20
Angled bus extension card for PCs	914030 ●	12.05	24.10
Sync separator	914077 ●	4.40	8.80

Printed circuit boards whose number is followed by a + sign are only available in combination with the associated software item, and can not be supplied separately. The indicated price includes the software.

Project	No.	Price (£)	Price (US$)
SEPTEMBER 1991			
Peak indicator for loudspeakers		ELV project	
Timecode interface for slide control:			
- main board	910055	24.40	48.80
- display board	87291-9a	4.10	8.20
Asymm-symm converter	910072	5.60	11.20
OCTOBER 1991			
PC-controlled weather station (2)	900124-2	3.80	7.60
Digital function generator			
- main board	910077-1	21.75	43.50
- display board	910077-2	12.65	25.30
Audio spectrum shift encoder/decoder	910105	10.35	20.70
NOVEMBER 1991			
Relay card for universal I/O interface	910038	12.95	25.90
Dissipation limiter	910071	4.40	8.80
Digital function generator			
- sine converter	910077-3	15.00	30.00
- R/T converter	910077-4	12.35	24.70
Class-A power amplifier (1):			
	880092-1	9.95	19.90
	880092-2	9.05	18.10
Timer for CH systems	UPBS-2	3.80	7.60
DECEMBER 1991			
Class-A power amplifier (2):			
	880092-3	7.50	15.00
	880092-4	7.60	15.20
Economy power supply	910111 ●	9.40	18.80
µP programmable filters	910125	6.75	13.50
Amiga mouse/joystick switch	914078	4.10	8.20
Safe solid-state relay	914008 ●	3.80	7.60
Slave mains on/off control Mark-2	914072 ●	6.45	12.90
Wideband antenna amplifier		ELV project	
1992			
JANUARY 1992			
CD player	910146	8.25	16.50
Fast precise thermometer	910081	8.50	17.00
Low-frequency counter			
- input board	910149-1	5.00	10.00
- display board	910149-2	6.45	12.90
Mini Z80 system	910060	10.60	21.20
Prototyping board for IBM PCs	910049	21.15	42.30
PC-controlled weather station (3)	900124-5	10.00	20.00
FEBRUARY 1992			
Audio/video switching unit	910130	11.75	23.50
I^2C interface for PCs	910131-1	14.40	28.80
Measurement amplifier	910144	13.50	27.00
Mini square wave generator	910151	5.30	10.60
RAM extension for mini Z80 system	910073	2.35	4.70
Switch-mode power supply	920001	4.40	8.80
MARCH 1992			
8751 emulator	920019	12.05	24.10
A-D/D-A and I/O for I^2C bus	910131-2	6.15	12.30
AF drive indicator	920016	5.60	11.20
Centronics line booster	910133	5.90	11.80
FM tuner (tuner board)	920005	21.15	42.30
LC meter	920012	8.80	17.60
MIDI optical link	920014	6.15	12.30
APRIL 1992			
80C32 SBC extension	910109	13.50	27.00
2-metre FM receiver	910134	10.30	20.60
Comb generator	920003	8.50	17.00
AD232 converter	920010	12.35	24.70
Automatic NiCd charger	UPBS-1	2.30	4.60
LCD for L-C meter	920018	4.70	9.40
Milli-ohm meter adaptor	920020	4.40	8.80
May 1992			
1.3-GHz prescaler	914059	5.00	10.00
Compact mains supply	920021	7.35	14.70
FM tuner - 3 (PSU)	920005-2	8.80	17.60
GAL programmer	920030	11.15	22.30
NICAM decoder	920035	15.00	30.00
JUNE 1992			
4-Megabyte printer buffer	910110	18.80	37.60
Audio-video processor - 2		ELV project	
I2C display	920004	4.70	9.40
FM tuner - 4:			
- mode control board	920005-3	5.60	11.20
- synthesizer board	920005-5	10.85	21.70
Guitar tuner	920033	10.00	20.00
Multi-purpose Z80 card	920002	20.25	40.50
JULY 1992			
12VDC to 240VAC inverter			
- main board	920039-1	11.15	22.30
- power board	920039-2	6.45	12.90
Audio DAC - 1	920063-1	8.50	17.00
Optocard for universal PC I/O bus	910040	12.95	25.90
Audio-video processor - 3		ELV project	
FM tuner - 5:			
- keyboard/display	920005-4	14.40	28.80
- S-meter	920005-6	3.80	7.60
RS232 quick tester	920037	5.00	10.00
Small projects:			
Water pump control for solar power system	924007	7.35	14.70
Simple power supply	924024	5.00	10.00
Wideband active telescopic antenna	924102	3.25	6.50
SEPTEMBER 1992			
EPROM emulator - II	910082	10.00	20.00
Audio/video processor - 4		ELV project	
Audio DAC - 2	920063-2	18.80	37.60
OCTOBER 1992			
Audio DAC - 3	920063-3	26.45	52.90
Mains sequencer	920013	17.35	34.70
Wideband active antenna	924101	3.25	6.50
RDS demodulator	880209 ●	5.30	10.60
NOVEMBER 1992			
Printer sharing unit	920011	14.70	29.40
Sound sampler for Amiga	920074	6.75	13.50
Difference thermometer	920078	5.30	10.60
Low-power TTL-to-RS232 interface	920127	3.55	7.10
DECEMBER 1992			
Digital audio/visual system (incl. EPROM 6171)	920022+	34.10	68.20
1.2 GHz multifunction frequency meter (incl. EPROM 6141)	920095+	29.40	58.80
Output amplifier for ribbon loudspeakers	920135-1	19.40	38.80
	920135-2	7.95	15.90
Peak-delta NiCd charger	920147	4.10	8.20
IDC-to-box header adaptor	924049	6.45	12.90
Mini keyboard for Z80	924047	12.35	24.70
80C552 µP system	924071	20.00	40.00
Mains power-on delay	924055	6.45	12.90
1993			
JANUARY 1993			
PAL test pattern generator (incl. GAL 6211)	920129+	15.30	30.60
Multi-core cable tester			
- matrix board	926079	17.05	34.10
- slave unit	926084	6.20	12.40
- master unit	926085	8.25	16.50
FEBRUARY 1993			
U2400B NiCd battery charger	920098	8.75	17.50
Digital-audio enhancer	920169	14.25	28.50
I^2C opto/relay card	930004	11.00	22.00
Watt-hour meter (PCBs -1 and -2, and EPROM 6241)	920148+	37.25	74.50
MARCH 1993			
Linear sound pressure meter	930006	7.00	14.00
Electrically isolated RS232 interface	920138	10.25	20.50
APRIL 1993			
Audio power meter	930018	10.25	20.50
Video digitizer for PCs (incl. disk 1831)	930007+	37.00	74.00
Infrared receiver for 80C32 single-board computer (incl. disk 1791)	920149+	14.50	29.00
4MB printer buffer card	920009	27.50	55.00
MAY 1993			
FM stereo signal generator	920155	23.00	46.00
VHF/UHF receiver	926001	19.00	38.00
Philips preamplifier	930003	7.50	15.00
Workbench PSU	930033	21.50	43.00
	920075-1	4.70	9.40
JUNE 1993			
Spectrum VU meter	920151	13.00	26.00
GAL programmer upgrade	930060	4.50	9.00
Digital frequency readout for VHF/UHF receiver	926001-2	11.50	23.00
Inexpensive phase meter			
- main board	930046	9.00	18.00
- meter board	920018	4.75	9.50
JULY/AUGUST 1993			
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock	930020	15.50	31.00
Four-fold DAC for PCs	930040	Kolter Electronic	
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I^2C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00

For September to December 1993 items see page 110 of this issue.

ROMS — EPROMS — PALS — GALS — MICROCONTROLLERS

Article/Project*	Issue	Order code	Description	Price (£)	Price (US$)
Multifunction measurement card for PCs	2/91	561	1 × 16L8	10.30	20.60
The digital model train	series	572	1 × 2764	11.75	23.50
Darkroom clock	2/90	583	1 × 27128	10.85	21.70
Video mixer	3/90	5861	1 × 2764	11.75	23.50
Four-sensor sunshine recorder	6/90	5921	1 × 27128	11.75	23.50
µP-controlled telephone exchange	10/90	5941	1 × 27128	15.30	30.60
RDS decoder	2/91	5951	1 × 2764	15.30	30.60
MIDI programme changer	4/91	5961	1 × 2764	15.30	30.60
Logic analyser	(series)		see under DISKETTES below		
Logic analyser (IBM interface)	6/91	5971	1 × PAL 16L8	8.25	16.50
MIDI-to-CV interface	2/91	5981	1 × 2764	15.30	30.60
Multifunction I/O card for PCs	7-8/91	5991	1 × PAL 16L8	8.25	16.50
Amiga mouse/joystick switch	12/91	6001	1 × GAL 16V8	8.25	16.50
Stepper motor board	6/91	6011	1 × PAL 16L8	8.25	16.50
4-MByte printer buffer (6/92 and 4/93)		6041	1 × 27C64	15.30	30.60
8751 emulator (incl. system disk 5.25 in.)	3/92	6051	1 × 27C64	29.40	58.80
EMON51 (incl. course disk 1661)	(series)	6061	1 × 27256	20.00	40.00
Connect 4	12/91	6081	1 × 2764	15.30	30.60
EMON51 (incl. course disk 1681)	(series)	6091	1 × 27256	20.00	40.00
FM tuner	7/92	6101	1 × 27C256	20.00	40.00
Multi-purpose Z80 card: GAL set	6/92	6111	2 × GAL 16V8	11.15	22.30
Multi-purpose Z80 card: BIOS	6/92	6121	1 × 27128	15.30	30.60
TV test pattern generator (80C32 SBC)	3/93	6151	1 × 27256	15.30	30.60
1.2 GHz multifunction frequency meter	12/92	6141	1 × 27C256	11.45	22.90
Digital audio/visual system	12/92	6171	1 × 27C256	10.30	20.60
Digital audio/visual system (software package)	2/93	6181	EPROM, GALs and disk	30.50	61.00
PAL test pattern generator	1/93	6211	1 × GAL 20V8	9.40	18.80
Watt-hour meter	2/93	6241	1 × 27256	10.00	20.00
Four fold DAC	7-8/93	6251	1 × GAL	10.75	21.50
Multipurpose display decoder	7-8/93	6261	1 × 2764	11.50	23.00
Digital hygrometer	11/93	6301	1 × 2764	14.50	29.00
8751 programmer	11/90	7061	1 × 8751	46.40	92.80
Microcontroller NiCd charger	10/93	7071	1 × ST62E15	10.00	20.00
Maxi micro clock (clock)	7-8/93	7081	1 × ST62T10	11.50	23.00
Maxi micro clock (darkroom timer)	7-8/93	7091	1 × ST62T10	11.50	23.00
Maxi micro clock (cooking timer)	7-8/93	7101	1 × ST62T10	11.50	23.00
Mini micro clock (clock)	9/93	7111	1 × ST62T15	11.50	23.00
Mini micro clock (darkroom timer)	9/93	7121	1 × ST62T15	11.50	23.00
Mini micro clock (cooking timer)	9/93	7131	1 × ST62T15	11.50	23.00
VHF/UHF TV tuner	11/93	7141	1 × 87C51	25.75	51.50

** For pre-1990 project EPROMs see the December 1992 Product Overview or contact our Dorchester office*

DISKETTES

Article/Project*	Issue	Order code	Disk size	Price (£)	Price (US$)
EPROM emulator II	9/91	129	5.25-inch	6.75	13.50
Multifunction measurement card (MMC) for PCs	2/91	1461	5.25-inch	7.65	15.30
Logic analyser: IBM software & GAL IC	7-8/91	1491	5.25-inch	19.40	38.80
Logic analyser: Atari software & GAL IC	7-8/91	1501	3.5-inch	19.40	38.80
Plotter driver (D. Sijtsma)	9/91	1541	5.25-inch	11.15	22.30
8-bit I/O interface for Atari ST	4/91	1571	3.5-inch	7.65	15.30
Tektronix/Intel file converter	4/91	1581	5.25-inch	7.65	15.30
B/W video digitizer for Archimedes	7-8/91	1591	3.5-inch	11.15	22.30
Timecode interface for slide controller	9/91	1611	5.25-inch	7.65	15.30
Real-time clock for Atari ST	6/91	1621	3.5-inch	7.65	15.30
24-bit colour extension for video digitizer	11/91	1631	3.5-inch	11.15	22.30
PC-controlled weather station (3) (supersedes 1551 and 1561)	1/92	1641	5.25-inch	7.65	15.30
8051/8032 assembler course (IBM version)	(series)	1661	5.25-inch	7.65	15.30
A-D/D-A and I/O for I^2C bus	3/92	1671	order as 1821 (see below)		
8051/8032 assembler course (Atari version)	series	1681	3.5-inch	7.65	15.30
AD232 converter	4/92	1691	5.25-inch	7.65	15.30
GAL programmer (upgrade: June 1993)	5/92 & 6/93	1701	5.25-inch (3 ×)	11.15	22.30
Multi-purpose Z80 card	6/92	1711	5.25-inch	7.65	15.30
Pascal routines for MMC for PCs	10/92	1751	5.25 inch	9.70	19.40
Speech/sound memory	12/92	1771	5.25 inch	7.65	15.30
PC-aided transistor tester	9/93	1781	3.5 inch	7.50	15.00
Infra-red receiver and DTMF decoder for 80C32 single-board computer	3 & 4/93	1791	5.35-inch	7.50	15.00
I^2C opto/relay card	2/93	1821	5.25 inch	7.65	15.30
Video digitizer for PCs	4/93	1831	5.25 inch	14.50	29.00
GAL programmer for Amiga	6/93	1841	3.5 inch	11.00	22.00
I^2C alphanumerical display	9/93	1851	5.25 inch	8.50	17.00
Philips preamplifier	5/93	1861	5.25 inch	8.50	17.00
GAL programmer (excl. Opal Jr. disks)	6/93	1881	5.25 inch	10.75	21.50
X2404-to-8751 interfacing	6/93	1891	5.25 inch	8.50	17.00

** For pre-1991 project diskettes see the December 1992 Product Overview or contact our Dorchester office*

SELF-ADHESIVE FRONT PANEL FOILS

Article/Project*	Issue	Order code	Price (£)	Price (US$)
Wattmeter	4/91	910011-F	9.70	19.40
Universal NiCd battery charger	6/91	900134-F	6.45	12.90
Logic analyser	(series)	900094-F	10.30	20.60
Digital phase meter	6/91	910045-F	11.75	23.50
Variable AC power supply	6/91	900104-F	16.45	32.90
Timecode interface for slide controller	9/91	910055-F	8.80	17.60
Digital function generator	10/91	910077-F	10.60	21.20
4-Megabyte printer buffer	6/92	910110-F	11.45	22.90
Economy power supply	12/91	910111-F	10.60	21.20
Measurement amplifier	2/92	910144-F	8.80	17.60
CD player	1/92	910146-F	12.05	24.10
FM tuner	(series)	920005-F	13.20	26.40
4-Megabyte printer buffer insertion card	3/93	920009-F	8.25	16.50
LC meter	3/92	920012-F	11.45	22.90
Digital audio/visual system	(series)	920022-F1	10.00	20.00
		920022-F2	19.40	38.80
		920022-F3	28.80	57.60
Guitar tuner	6/92	920033-F	8.80	17.60
NICAM decoder	5/92	920035-F	8.25	16.50
12VDC-to-240VAC inverter	7/92	920038-F	16.15	32.30
Audio DAC	10/92	920063-F	10.00	20.00
1.2GHz multifunction frequency meter	12/92	920095-F	13.80	27.60
U2400B NiCd battery charger	2/93	920098-F	8.75	17.50
Workbench PSU	4/93	930033-F	17.00	34.00
Inexpensive phase meter	6/93	930046-F	17.25	34.50

** For 1990 project front panel foils see the September 1993 Product Overview or contact our Dorchester office*

READERS SERVICES

Except in the USA and Canada, all orders, except for subscriptions and past issues (for which see below), must be sent BY POST to our Dorchester office using the appropriate form opposite. Please note that we can not deal with PERSONAL CALLERS, as no stock is carried at the editorial and administrative office.
Readers in the USA and Canada should send orders, except for subscriptions (for which see below), to Old Colony Sound Lab, Peterborough, whose full address is given on the order form opposite. Please include shipping cost according to total order value. For surface delivery in the USA, if order is less than $50, include $3; $50+, $4. For Canada surface, if less than US$50, include US$5; US$50+, US$7.50. For air or other deliveries, please inquire. Please allow 4-6 weeks for delivery.
All other customers must add postage and packing charges for orders up to £25.00 as follows: UK and Eire £1.95; surface mail outside UK £2.45; Europe (airmail) £2.95; outside Europe (airmail) £3.70. For orders over £25.00, but not exceeding £100.00, these p&p charges should be doubled. For orders over £100.00 in value, p&p charges will be advised.

SUBSCRIPTIONS & PAST ISSUES

Subscriptions and past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England**. For subscriptions, use the order form on the opposite page. Prices of past issues (except July/August and December), including postage for single copies, are £2.70 (UK and Eire); £3.00 (surface mail outside UK); £3.20 (air mail Europe); £3.95 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £3.75 (UK); £4.00 (surface mail outside UK); £4.25 (airmail Europe); and £5.00 (airmail outside Europe).

PAST ARTICLES

Photocopies of articles from January 1978 onwards can be provided, postage paid, at £1.95 (UK and Eire), £2.10 (surface mail outside UK), £2.45 (airmail Europe), or £2.70 (airmail outside Europe). In case an article is split into instalments, these prices are applicable **per instalment**. Photocopies may be ordered from our editorial and administrative offices.

COMPONENTS

Components for projects appearing in *Elektor Electronics* are usually available from appropriate advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. It should be noted that the source(s) given is (are) not exclusive — other suppliers may also be able to help.

BOOKS

For book availability, see advertisement on page 99.

SHELF BOX

Elektor Electronics shelf box ....£2.95............$6.00

FRONT PANELS

PROJECT	No.	Price (£)	Price (US$)
Timecode interface	910055-F	8.80	17.60
Digital function generator	910077-F	10.60	21.20
4-Megabyte printer buffer	910110-F	11.45	22.90
FM tuner	920005-F	13.20	26.40
4MB printer buffer card	920009-F	8.25	16.50
LC meter	920012-F	11.45	22.90
Guitar tuner	920033-F	8.80	17.60
NICAM decoder	920035-F	8.25	16.50
12VDC to 240VAC inverter	920038-F	16.15	32.30
Audio DAC	920063-F	10.00	20.00
Dig. audio/visual system	920022-F1	10.00	20.00
	920022-F2	19.40	38.80
	920022-F3	28.80	57.60
1.2 GHz multifunction frequency meter	920095-F	13.80	27.60
U2400B NiCd battery charger	920098-F	8.75	17.50
Workbench PSU	930033-F	17.00	34.00
Inexpensive phase meter	930046-F	17.25	34.50
MIDI channel monitor	930059	Not available	
Ah meter w. digital readout	930068	Not available	
Autoranging frequency readout	930034	Not available	
Electronic load	930088	Not available	
AF rms voltmeter	**930108-F**	**17.25**	**34.50**

EPROMS / PALS / MICROCONTROLLERS

PROJECT	No.	Price (£)	Price (US$)
Amiga mouse/joystick switch (1 × GAL 16V8)	6001	8.25	16.50
4-Megabyte printer buffer (1 × 2764)	6041	15.30	30.60
8751 emulator incl. system disk (MSDOS)	6051	29.40	58.80
Connect 4 (1 × 27C64)	6081	15.30	30.60
EMON51 (8051 assembler course) (1 × 27256 +disk 1661)	6061	20.00	40.00
EMON51 (8051 assembler course) (1 × 27256 +disk 1681)	6091	20.00	40.00
FM tuner (1 × 27C256)	6101	20.00	40.00
Multi-purpose Z80 card: GAL set (2 × GAL 16V8)	6111	11.15	22.30
Multi-purpose Z80 card: BIOS (1 × EPROM 27128)	6121	15.30	30.60
1.2 GHz multifunction frequency meter(1 × 27C256)	6141	11.45	22.90
Digital audio/visual system (1 × 27C256)	6171	10.30	20.60
TV test pattern generator (1 × 27256)	6151	13.00	26.00
DiAV system. Package: 1 × 27512; 2 × GAL; 1 × floppy disk (MSDOS)	6181	30.50	61.00
PAL test pattern generator (1 × GAL 20V8-25)	6211	9.40	18.60
Watt-hour meter (1 × 27256)	6241	10.00	20.00
Four fold DAC (1 × GAL)	6251	10.75	21.50
Multipurpose display decoder (1 × 2764)	6261	11.50	23.00
Relative humidity meter (1 × 2764)	6301	14.50	29.00
535 card w. EPROM emulator (1 × PAL; 1 × GAL)	**6311**	**26.00**	**52.00**
8751 programmer (1 × 8751)	7061	46.40	92.80
Microcontroller NiCd charger (1 × ST62E15)	7071	10.00	20.00
Maxi micro clock (clock)	7081	11.50	23.00
Maxi micro clock (darkroom timer)	7091	11.50	23.00
Maxi micro clock (cooking timer)	7101	11.50	23.00
Mini micro clock (clock)	7111	11.50	23.00
Mini micro clock (darkroom timer)	7121	11.50	23.00
Mini micro clock (cooking timer)	7131	11.50	23.00
VHF/UHF TV tuner (1 × 87C51)	7141	25.75	51.50
Microntroller-driven UART (1 × ST62T10)	**7151**	**17.25**	**34.50**

DISKETTES

PROJECT	No.	Price (£)	Price (US$)
Plotter driver (D. Sijtsma)	1541	11.15	22.30
I/O interface for Atari	1571	7.65	15.30
Tek/Intel file converter	1581	7.65	15.30
B/W video digitizer	1591	11.15	22.30
Timecode interface	1611	7.65	15.30
RTC for Atari ST	1621	7.65	15.30
24-bit colour extension for video digitizer	1631	11.15	22.30
PC controlled weather station - 3 (supersedes disks 1551 and 1561)	1641	7.65	15.30
8051/8032 Assembler course (IBM version)	1661	7.65	15.30
8051/8032 Assembler course (Atari version) (3.5")	1681	7.65	15.30
AD232 converter	1691	7.65	15.30
GAL programmer (3 disks; upgrade: June 1993)	1701	11.15	22.30
Multi-purpose Z80 card	1711	7.65	15.30
Fuzzy Control One	1721	7.75	15.50
Pascal library for MMC	1751	9.70	19.40
Speech/sound memory	1771	7.65	15.30
PC-aided transistor tester	1781	7.50	15.00
IR receiver and DTMF decoder for 80C32 SBC	1791	9.00	18.00
I^{2}C opto/relay card	1821	7.65	15.30
Video digitizer for PCs	1831	14.50	29.00
GAL programmer for Amiga	1841	11.00	22.00
I^{2}C alphanumerical display	1851	8.50	17.00
Philips preamplifier	1861	8.50	17.00
GAL programmer (excl. Opal Jr. disks)	1881	10.75	21.50
Precision clock for PCs	1871	8.50	17.00
X2404-to-8751 interfacing	1891	8.50	17.00

PRINTED CIRCUIT BOARDS

Printed circuit boards whose number is followed by a + sign are only available in combination with the associated software item, and can **not** be supplied separately. The indicated price includes the software.

JULY/AUGUST 1993

PROJECT	No.	Price (£)	Price (US$)
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock	930020	15.50	31.00
Four-fold DAC for PCs	930040	Kolter Electronic	
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I^{2}C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00

SEPTEMBER 1993

PROJECT	No.	Price (£)	Price (US$)
Fuzzy logic multimeter - 1	920049-2	20.00	40.00
Linear temperature gauge	920150	7.05	14.10
Digital output for CD players	920171	Not available	
PC-aided transistor tester	920144	9.75	19.50
Harmonic enhancer	930025	13.50	27.00
I^{2}C alphanumerical display incl. disk (1851)	930044+	14.25	28.50
Mini micro clock	930055	7.50	15.00
950-1750 MHz converter	UPBS-1	1.95	3.90

OCTOBER 1993

PROJECT	No.	Price (£)	Price (US$)
Stereo mixer	UPBS-1	1.95	3.90
MIDI channel monitor	930059	14.00	28.00
Ah meter with digital display	930068	14.00	28.00
Autoranging frequency readout	930034	12.50	25.00
ROM-gate switchover for Atari ST	930005	30.25	60.50
Microntroller-driven NiCd battery charger (incl. programmed ST62E15)	920162+	25.50	51.00
Fuzzy logic multimeter - 2 incl. disk (1721)	920049-1+	23.75	47.50

NOVEMBER 1993

PROJECT	No.	Price (£)	Price (US$)
Fuzzy logic multimeter - 3 (four boards)	920049	Not available	
Precision clock for PCs incl. disk (1871)	930058+	12.25	24.50
VHF/UHF TV tuner boards -1 and -2, and µC 87C51 (7141)	930064+	57.25	114.50
Output amplifier with AF bandpass filter	930071	6.75	13.50
Electronic load	930088	Not available	
Digital hygrometer incl. EPROM (6301)	930104+	28.00	56.00
Power MOSFET tester	930107	32.50	65.00

DECEMBER 1993

PROJECT	No.	Price (£)	Price (US$)
535 card w. EPROM emulator incl. GAL and PAL (6311)	930103+	47.50	95.00
AF rms voltmeter	930108	12.25	24.50
I^{2}C power switch	930091	6.25	12.50
Medium power HEXFET amplifier	930102	12.75	25.50
Microcontroller driven UART	930073	4.75	9.50
SCART switching box	930122	14.25	28.50
Low-power NBFM transmitter	914114	Not available	
Photographic workshop light	930116	Not available	
Stereo PWM output amplifier	934076	Not available	

A list of all PCBs, software products and front panels available through the Readers Services is published in the March, June, September and December issues of *Elektor Electronics*.

ORDER FORM

12-93

VAT No.GB 454 135 463

Send this order form to *
Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
ENGLAND

**USA and Canada residents only:* use $ prices, and send order form to:
Old Colony Sound Lab,
P.O. Box 243, Peterborough, NH 03458.
Tel. (603) 924-6371, 924-6526
Fax: (603) 924-9467

Name
Address

Post code
Telephone Date

Please supply the following. For PCBs, front panel foils, EPROMs, PALs, GALs, microcontrollers and diskettes, state the part number and description; for books, state the full title; for photocopies of articles, state full name of article and month and year of publication. Please use block capitals.

Qty.	Order code	Description	Price	Total
			Sub-total	
			P&P	
			Total paid	

Method of payment (see overleaf before ticking as appropriate)
Note: cheques not made out in sterling must be increased by the equivalent of £15.00

☐ Bank draft ☐ Cheque (payable to Elektor Electronics Publishing)
☐ Giro transfer (our account no. 34 152 3801)
☐ Postal/money order
☐ VISA Access MasterCard Eurocard Expiry date: ________ Signature:

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

International Subscription Service

Please enter my subscription to *Elektor Electronics*
for ☐ one year ☐ two years (tick as required)
by ☐ surface mail ☐ airmail (tick as required).
Method of payment (see overleaf before ticking as appropriate)
☐ Cheque enclosed (payable to Elektor Electronics Publishing)
☐ Giro transfer to a/c 34 152 3801
☐ Credit card Expiry date..............Signature ....

VISA Access MasterCard Eurocard ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Name ....
Address ....
....
.....................................Postal code ....
Telephone .... Date ....

Send this form to
Elektor Electronics, World Wide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, Ticehurst TN5 7HE, England
(Registered in the UK under the Data Protection Act, 1984)

12-93

TERMS OF BUSINESS

HOW TO PAY

Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated on page 70, section 1.

Payment may be made by cheque **drawn on a London clearing bank** (but see para. 4 below), postal order, VISA, ACCESS, MASTERCARD or EUROCARD (when paying by credit card, the order must go to the cardholder's address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to 'Elektor Electronics (Publishing)'.

Payment may also be made by direct transfer from a private or business Giro account to our **Giro Account No. 34 152 3801** by completing and sending to the National Giro Centre, in a National Giro postage paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order.

If you live outside the UK, payment may also be made by Bankers' sterling draft drawn on a London clearing bank, Eurocheque **made out in pounds sterling** (with holder's guarantee card number written on the back), or US or Canadian dollar cheque, but such cheques, accepted at the exchange rate prevailing at the time your order is received, **must be increased by the equivalent of £15.00** to cover our bankers' negotiating fee.

If you pay by Bankers' sterling draft, make clear to the issuing bank that your full name and address MUST be communicated to the London clearing bank.

Our bankers are **National Westminster Bank PLC, 100 High Street, BRENTFORD TW8 8AY, England.** Our account number is **4285 0134**.

DELIVERY

Although every effort will be made to dispatch your order within 2–3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders.

RETURNS

Faulty goods or goods sent in error may be returned for replacement or correction, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Goods returned for refund must be in resaleable condition and will be subject to a 10% handling charge with a minimum charge of £2·50.

DAMAGED GOODS

Claims for damaged goods must be received at our Dorchester office within 10 days (UK); 14 days (Europe) or 21 days (all other countries) from the date on our "Recorded Delivery" slip.

CANCELLED ORDERS

All cancelled orders will be subject to a 10% handling charge with a minimum charge of £2·50.

PATENTS

Patent protection may exist in respect of circuits, devices, components, and so on, described in our books or magazines. Elektor Electronics (Publishing) do not accept responsibility or liability for failing to identify such patent or other protection.

COPYRIGHT

All drawings, photographs, articles, printed-circuit boards, EPROMS, and cassettes published in our books or magazines (other than in third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature.

Nothwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission.

LIMITATION OF LIABILITY

Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods.

LAW

Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

April 1993

Annual subscription rates (1994)

United Kingdom	£27·00
Rest of the world (surface mail)	£33.00
AIRMAIL	
Europe & Eire	£34.00
USA & Canada	$57.00
Middle East & North Africa	£43·00
Central & southern Africa	£43·00
Central & South America	£43·00
Australia & New Zealand	£45·00
Far East & South Pacific regions	£45·00

Payment may be made by cheque in sterling **drawn on a London clearing bank** (but see below), postal order, VISA, ACCESS, MASTERCARD or EUROCARD (in which case the subscription must be sent to the cardholder's address) or by direct transfer to our Giro Account no. 34 152 3801. Do not send cash through the mail. Cheques and postal orders should be made payable to 'Elektor Electronics Publishing'. Giro transfers should be made by completing and sending the appropriate transfer/deposit form to the National Giro Centre (UK) or to your national Giro Centre.

If you live outside the United Kingdom, payment may also be made by Bankers' sterling draft drawn on a London clearing bank or Eurocheque. Eurocheques should be made out in pounds sterling and have the holder's guarantee card number written on the back.

US dollar cheques. Subscribers in the USA and Canada only may pay in $US cheques.

The **standard subscription order period** is twelve months. If a permanent change of address during your subscription period means that copies have to be dispatched by a more expensive service, no extra charge will be made. Similarly, no refund will be made, nor expiry date extended, if a change of address allows the use of a cheaper service.

Student applications, which qualify for a 10% (ten per cent) reduction in current rates, must be supported by evidence of studentship signed by the head of the college, school or university faculty.

Please note that **new subscriptions** take about four weeks from receipt of order to become effective.

Cancelled subscriptions will be subject to a charge of 25% (twenty-five per cent) of the full subscription price or £7.50, whichever is the higher, plus the cost of any issues already dispatched. Subscriptions cannot be cancelled after they have run for six months or more.

Our bankers are National Westminster Bank PLC, Sorting Code 60-03-23, 100 High Street, Brentford TW8 8AY, England. Our account number is 4285 0134.

June 1993

WHAT'S ON IN DECEMBER

WIN £1000 IBM PC AT CHRISTMAS COMPUTER SHOPPER SHOW

Book your ticket in advance for the Christmas Computer Shopper Show and not only do you save time queuing and money off the entry price, but your name will automatically be entered into a prize draw to win an IBM PS/1 486 SX/25. Worth over £1000, this computer comes with pre-loaded software, Super VGA monitor and a mouse. Alternatively, use the coupon on page 57 to save £1.50 on the entry price to the show.

The Computer Shopper Shows (see also page 64) are user-friendly offering a unique opportunity to meet companies who sell direct,meaning there are better deals to be had than you'll find anywhere else. The Christmas Computer Shopper Show has manufacturers, software publishers and suppliers and, with two shows a year attracting more than 60,000 visitors annually, it is the largest consumer computer show in the UK. Exhibitors include IBM, P&P, Compusys, Kamco, Mannesmann Tally and Roland.

The Christmas Computer Shopper has many special features designed purely to help visitors. The Independent Advice Centre will be open daily to offer free and impartial advice to individual visitors' needs and is staffed by journalists from the *Computer Shopper* magazine. Special presentations of new software will be shown in the Software Theatre with the opportunity to have any questions answered.

Also at Christmas Shopper will be a dedicated advice centre on solutions for businesses – especially for small businesses and home workers. Not forgetting the fun side of computing, the Games and Leisure Area offers the chance to try out all the latest games software for PCs and Macs before buying; visitors can take part in the ingenious competitions arranged for the event.

The prize winner will be drawn at the Christmas Computer Shopper Show which takes place at the Grand Hall, Olympia, London, 2–5 December. Advance ticket prices are £5·00 for adults, £3·50 for under-16s, and £16·00 for a family of four (valuable savings of £2·00, £1·50 and £5·50 respectively).

Booking your ticket in advance and entering the prize draw is simple: just phone the Olympia Box Office on 071 373 8141. Tickets can be paid by cheque, Access or Visa.

TTI SEMINARS

Technology Transfer Institute has recently set up a UK office to serve the European market. Since TTI was founded in 1976, in America, over 40,000 IT professionals have attended TTI events round the world. The UK office has already run one successful conference in Copenhagen and have now planned the following seminars for December:

2–3 Dec—Information Systems Architecture. at the American Hotel, Amsterdam.

6–7 Dec—Business Process Reengineering at the Hotel Inter-Continental, London.

8–9 Dec—Business Process Reengineering at the American Hotel, Amsterdam.

6–10 Dec—Analysis and Design of Client/Server - GUI Applications at the Regents Park Hilton, London.

MOBILE AND PERSONAL COMMUNICATIONS CONFERENCE

The Seventh IEE European Conference on Mobile and Personal Communications will be held at the Brighton Centre, Brighton, on 13–15 December.

The aims of the conference are to encourage engineers, operators and regulators to discuss topics relevant to this subject, to provide general background information to those new to the subject and to provide a forum for exchanging information and experience on new developments.

Details from The Institution of Electrical Engineers, Savoy Place, London; Telephon 071 240 1871.

SWITCHBOARD

Switchboard allows all PRIVATE READERS of *Elektor Electronics* one FREE advertisement of up to 108 characters, including spaces, commas, numerals, etc., per month.

Write the advertisement, which MUST relate to electronics, in the coupon on this page; it MUST INCLUDE a private telephone number or name and address; post office boxes are NOT acceptable.

Elektor Electronics (Publishing) can not accept responsibility for any correspondence or transaction as a result of a free advertisement or of any inaccuracy in the text of such an advertisement.

Advertisements will be placed in the order in which they are received.

Elektor Electronics (Publishing) reserve the right to refuse advertisements without giving reasons or without returning them.

WANTED. PCBs or artwork for valve preamplifier featured in March/April 1987 issue of *Elektor Electronics*. Phone Roy on (0705) 597 029.

WANTED by student: old microphone spares and related bits. Broken items welcome. Phone (0273) 552 985.

WANTED. XU620 for XP640 EPRM programmer. Cash or will swap for XM512 emulation units. Phone (0827) 285 258.

FOR SALE. Variac 0–270 V, £50. Multi-function signal generator, £50. Phone Ron on 081 524 7308.

HELP! I need a circuit diagram for an Excel 20 inch monitor made by Nevin; do you own one? Cash waiting. Phone (0902) 781 599.

FOR SALE. Marconi SE Labs EM102 solid-state portable 30 MHz, TB delay, true dual-beam, V bright PDA Int, grat. £135. Scopex 10 MHz portable scope. Dual beam. Good condition. £75. Phone Alan (0344) 27869.

FOR SALE. VLF add-on unit for oscilloscopes *Elektor* Feb 87, £50. 19 kHz calibrator, *Elektor* March 85, £25. Break-out box, £25. Phone (0903) 242 927.

WANTED. *Elektor* magazine issues 1, 2, 3, 4, 5, 6, 7, 9, 12, 13, 14. Good price for clean copies. Call Steve on (046) 454 958.

FOR SALE. Dataman Soft Y4 EPROM programmer/emulator; 8 months old. Phone Richard on (0225) 874 138.

WANTED. Metal detector kit *Elektor* Nov. 1981; any condition. Circuit diagrams, parts, search heads. Please write to Mr J.D. Reece, 12 Railway Cottages, Station Road, Whitstable, Kent CT5 1JZ.

FOR SALE. FX850P pocket computer + interface (parallel, RS232, tape) + tape lead. £80. Phone Paul on (0992) 467 928.

WANTED. Matshushita graphic/BT/AD70 circuit diagram fax/copier. Photocopies acceptable. Phone Don on (0202) 302 213.

FOR SALE. Optonica tuner/amp SA5101E; MW & VHF; 33 W per channel; full working order; £35·00. Phone (0362) 696 993.

HELP! Can anyone suggest a source of 210 kV ≥20 mA fast diodes for my home-brew switch-mode PSU? Phone Alan on 081 800 0982.

FOR SALE. Kenwood TH-26E hand-held 2 m transceiver, almost brand new. £145. Phone 091 262 7532.

Send this coupon to
Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
England

Block capitals please – one character to each box

ELEKTOR ELECTRONICS 12/93

Name and address MUST be given

ELEKTOR ELECTRONICS is available from, among others:

CRICKLEWOOD ELECTRONICS LIMITED
40 Cricklewood Broadway,
London NW2 3ET
Telephone 081 450 0995
Fax 081 208 1441

THE ELECTRONIC SHOP
Electronic components, test equipment, telephone accessories, computer accessories, microphones, disco lighting, speakers, turn tables, mixers, meters, stylus.
29 Hanging Ditch,
Manchester M4 3ES,
Telephone 061 834 1185

ELEY ELECTRONICS
100–104 Beatrice Road
Leicester LE3 9FF
Telephone (0533) 515 944

GREENWELD
27 Park Road
Southampton SO1 3TB
England
Telephone (0703) 236 363
Fax (0703) 236 307

L.F. HANNEY
Your electronic component specialist for Avon, Wilts & Somerset.
77 Lower Bristol Road, Bath,
Avon, Telephone 0225 424811

D.P. HOBBS (NORWICH) LTD
Electronic component specialists. Amateur radio equipment.
13 St. Benedict Street,
Norwich NR2 4PE,
Telephone 0603 615786

MANCOMP
240 Platt Lane
Manchester M14 7BS
England
Telephone 061 224 1888

OMNI ELECTRONICS
Stock a wide range of electronic components.
174 Dalkeith Road,
Edinburgh EH16 5DX,
Telephone 031 667 2611

AAGE NIELSEN
1 Sortedam Dosseringen
DK-2200 Copenhagen,
Denmark,
Telephone 01 39 30 10
Fax 031 39 05 02

HELMHOLT ELEKTRONIK
Farvevej 2
DK-7600 Struer, Denmark
Telephone 97 85 26 11

RCE ELECTRONIC CENTRE
Boulevarden 34
DK-9000 Aalborg, Denmark
Telephone 98 16 07 10

VEJLE RC ELEKTRONIK
Sdr Brogade 42
P O Box 332
DK-7100 Vejle, Denmark
Telephone 75 83 25 33

BEBEK ELECTRONICS
Hirsimetsäntie 26
SF-15200 Lahti 11
Finland
Telephone (18) 33 99 46

TABACCARIA BRITANICA
Praça do Duque da Terceira 19
1107 Lisboa, Portugal
Telephone 932 4752

MK KNJIGARNA
Slovenska 29
Ljubljana
Slovenia
Telephone 061 150 196

TECHNICAL BOOKS & MAGAZINES
289-299 Swanston Street
Melbourne, Australia 3000
Telephone 663 3951

INEL Co.
P.O. Box 1397
JL. Hariang Banga No. 3
Bandung 40116
Indonesia

INDEX OF ADVERTISERS

Advertising Standards Authority	40, 75
Badger Boards	75
Baylin Publications	61
B K Electronics	41
Bull Electrical	100
Canal Bridge Audio	43
C-I Electronics	67
Cirkit Distribution	37
Comdis Nederland	43
Cricklewood Electronics	79
Display Electronics	104
Dubery	40
Electronics - the Maplin Magazine	66
ElectroValue	75
Elektor Electronics	40, 58, 99
ESR Electronic Components	47
Hitex (UK) Ltd	61
ICE Technology	Inside back cover
Instrutek	33
J P Distribution	43
Kare Electronics	67
Labcenter	71
Lloyd Research	23
Macro Cross Assemblers	79
Maplin Electronic Supplies	Back cover
MicroAmps	37
Microgem Systems	61
Number One Systems Ltd	4
Pico Technology Ltd	105
POWERware	55
Robinson Marshall	Inside front cover
Roline Systems	51
Stewart of Reading	67
Suma Designs	69
Telnet	37
Those Engineers	75
Tsien (UK) Ltd	91
Ultimate Technology	59
Viewcom Electronics	14, 15
White House Systems	79

ADVERTISING SPACE

for the January 1994 issue may be reserved not later than 18 November 1993 by

Elektor Electronics (Publishing)
Advertisement Office
3 Crescent Terrace
Cheltenham GL50 3PE
England
Telephone (0242) 510 760; Fax (0242) 226 626

to whom all correspondence, copy instructions and artwork should be addressed.

THE BEST LOW COST PROGRAMMERS
DESIGNED & MANUFACTURED IN THE UK

SPEEDMASTER 1000
SPEEDMASTER 1000E

UNIVERSAL PROGRAMMER

- Superfast PC based programmer
- Programmes; EPROMS UP TO 8M BIT, FLASH EPROMS, EEPROMS, BPROMS, NVRAMs, MICROs (8748/51), PALs, GALs, EPLDs, PEELS, MACHS, MAPLs, MAX
- Plugs directly into parallel port
- 1000E Version has ROM/RAM emulator built in: 128k (1 Mbit) standard, optional 512K (4Mbit)

only £445

only £525

MICROMASTER 1000
MICROMASTER 1000E

UNIVERSAL PROGRAMMER

- Programmes: EPROMS UP TO 8M BIT. FLASH EPROMS, EEPROMS, BPROMS, NVRAMs, PALs, GALs, EPLDs, PEELs, MACHs, MAPLs, MAX etc.
- PLUS over 80 different Micros including 8748/51, 68HC705, 68HC711, PICs, Z86, TMS320, TMS370 etc DIPs WITHOUT ADAPTORS OR PERSONALITY MODULES!
- Package adaptors available.
- 1000E Version has ROM/RAM emulator built in: 128K (1Mbit) standard, optional 512K (4 Mbit)

only £575

only £645

SPEEDMASTER 8000
GANG/SET PROGRAMMER

- 8 way, Pc or stand alone
- Super-fast programming times, manufacturer recommended algorithms
- 32 pin devices as standard
- Support for 8748,51, TMS370, PIC Micros and 40 pins.

only £645

Now includes digital IC and RAM tester

WHY BUY AN INFERIOR IMPORTED PROGRAMMER WHEN YOU CAN HAVE A MANUFACTURER APPROVED UNIVERSAL PROGRAMMER/EMULATOR DIRECT FROM ICE TECHNOLOGY!

- ☐ We offer the best range of low-cost programmers available, now including our unique **UNIVERSAL PROGRAMMERS WITH BUILT IN EMULATORS**
- ☐ Unrivalled device support, for example the Micromaster 1000 programmes PICS, Z86, 87C705, 68HC705, TMS370, 77C82 ETC WITHOUT ADAPTORS, as well as the full range of Eproms, PLDs etc supported by all our universal programmers.
- ☐ Approved by National Semiconductor for their full range of PALs, GALs, and MAPLs - other programmers claiming approval are often only approved for EPROMs - a much less exacting specification!
- ☐ All our programmers and programme/emulators work off the standard parallel port with any IBM compatible PC, even laptops
- ☐ Unbeaten programming times: Programme a 27256 in just 5 SECONDS including download and verify.
- ☐ Easy upgrade path between Models.

FOR MORE DETAILS, DEVICE LIST AND DEMO DISK CALL NOW ON

TEL +44 (0)226 767404 FAX +44 (0)226 370434

ICE TECHNOLOGY LTD, UNIT 4, PENISTONE COURT, STATION BUILDINGS, PENISTONE, S. YORKS, S30 6HG, UK.

ICE TECHNOLOGY

NEW

FULL COLOUR GUIDE TO ELECTRONIC PRODUCTS

Maplin

BSI
REGISTERED STOCKIST

BS 5750
Part 2 1987
Level B:
Quality Assurance
RS12750

Order your copy of the New MAPLIN Catalogue on sale NOW!

Pick up a copy from any branch of WHSMITH, selected branches of RSMcCOLL in Scotland ONLY, and Maplin stores nationwide for just £2.95 or post this coupon now to receive your copy for just £3.45 inc. p&p. If you live outside the U.K. send £6.80 or 18 IRC's for Airmail in Europe/£5.20 or 13 IRC's for surface mail outside Europe; or £11.50 or 30 IRC's for Airmail outside Europe.
I enclose £3.45/£6.80/£5.20/£11.50 (delete as applicable).

Name..

Address..

....

.... Post Code..

Send to Maplin Electronics,
P.O. Box 3, Rayleigh,
Essex, England
SS6 8LR.

ELK94

Over 700 colour packed pages with hundreds of brand New Products at Super Low Prices, on sale now, **only £2.95.**

Available from all branches of **WHSMITH**, selected branches of **RSMcCOLL** in Scotland ONLY, and Maplin stores nationwide.
The Maplin Electronics 1994 Catalogue – **UNIQUELY DIFFERENT!**

Africa customers please contact MAPLIN (SOUTH AFRICA) Tel: (024) 51-5124